A SEARCH FOR FAINT VIOLET STARS

by

Sompongse Jaidee, B.Sc. (Second Class Hons.)

submitted in fulfilment of the requirements
for the Degree of

Master of Science

UNIVERSITY OF TASMANIA

HOBART

September, 1968

The original work reported in this thesis is that of the candidate alone with exceptions as noted in the text.

ACKNOWLEDGEMENTS

I would particularly like to thank my supervisor, Dr. G. Lyngå, for his guidance, encouragement, discussion, criticism and for giving me so freely of his time.

I wish to thank Professors G.R.A.Ellis and T. Dunham who arranged for me to come to study at the Mt. Stromlo Observatory.

I am glad to acknowledge my indebtedness to Professor E. Holmberg and the Uppsala Observatory for making available Schmidt telescope of the Uppsala Southern Station.

I am grateful to Professor O.J. Eggen who made available the telescopes and facilities of the Mt. Stromlo and Siding Spring Observatories. I am also grateful to the Mt. Stromlo and Siding Spring's staff for their warm hospitality.

It is my pleasant duty to thank Dr. L. Searle for obtaining spectra of some stars, to Dr. B.E. Westerlund for photoelectric observations and to Dr. J. Shimmins for checking the positions of the violet stars against Parkes radio sources. I thank Dr. A. Sandage and Mr. A.L. Brooke for letting me use some unpublished data.

I would particularly like to thank Mr. J.N. Boots for the correction of the draft of my thesis.

For financial support provided by the Colombo Plan Scholarship, I am exceedingly grateful.

It is my pleasure finally to thank the University of Tasmania for accepting me as M.Sc. candidate. During the time of the scholarship I am on leave from Chulalongkorn University, Bangkok, Thailand.

TABLE OF CONTENTS

SUMMARY

296 faint violet stars (with U - B < - $0^m.6$) were found on U, B plates in 540 square degrees. Of these, 43 were measured photoelectrically in UBV and of those 43, 25 were measured also in a red colour R'. Two-colour diagrams in (U - B, B - V), (U - B, V - R') and (B - V, V - R') of the measured stars were studied. Two stars (Nos. 48, 288) show very strong infra-red as well as ultra-violet and these may well be quasi-stellar galaxies. From the space distribution of the violet stars, we expect white dwarfs to be prevalent in our material. However, about a dozen quasi-stellar

galaxies can be expected to be present as well.

Chapter I deals with the earlier surveys for faint blue stars. Completeness of the surveys, methods used and types of stars involved are discussed.

Chapter II gives a description of the observations made by the author with a discussion on the methods used to search for faint violet stars. It also includes the photoelectric results of the sampled violet stars.

Chapter III discusses colours of stars found in this type of survey. A two-colour diagram in (U - B, B - V) of known hot subdwarfs (O - B), white dwarfs, quasi-stellar objects, blue horizontal-branch stars and subdwarfs (F - G) is studied. To try to single out extra-galactic objects among the violet stars, two colour diagrams in (U - B, B - V), (U - B, V - R') and (B - V, V - R') are studied.

In chapter IV estimates are given of the expected yield of this survey as deduced from the space distribution of the types of stars concerned.

CHAPTER I

SOME PREVIOUS BLUE STAR SEARCHES

1.1 Introduction

The pioneers in the search for faint blue stars were Humason and Zwicky (1947). They surveyed the area around the north galactic pole and the Hyades region. By 1947 their observations were complete and they had listed 48 blue stars known as HZ stars. It appeared that this list included white dwarfs as well as blue halo stars.

The most noted worker in this field is Professor W.J. Luyten who has been publishing several catalogues from 1952 onwards. Others, who have also published lists of blue stars include Iriarte and

Chavira (1957), Chavira (1958, 1959), Cowley (1958), Feige (1958) and Haro (1962) working in conjunction with Luyten. So far more than 20400 blue stars have been listed: 817 stars by Iriarte and Chavira, 1136 stars by Chavira, 93 stars by Cowley, 114 stars by Feige and more than 18300 stars by Luyten (of these 8746 stars were found in collaboration with Haro). These stars were found around the north and south galactic poles, in the far southern hemisphere, in galactic clusters such as the Hyades and Praesepe, and in some of Kapteyn's selected areas.

1.2 Methods

1.2.1 Spectral classification

Cowley (1958) used spectral plates searching for early-type stars in high galactic latitudes. Spectra were photographed with the focus centred at $\lambda 3950$. These plates were suitable for finding stars of early types because they showed the relative strength of the K line compared with the He lines (as well as the characteristic spectrum at the violet end).

Cowley was able to identify the blue stars on the plates but these plates only gave spectra of stars brighter than the 12th photographic magnitude.

1.2.2 Colour studies

Humason, Zwicky, Feige, Luyten and Luyten's co-workers blinked pairs of plates taken with two different plate-filter combinations, generally one in blue and the other in red. As used by Luyten, initially, exposure times were chosen so that images (through blue and red filters) of a star of class G were of equal intensity on a pair of plates. The exposure times for the two filters were maintained for the remaining plates.

By this technique, blue stars were detected because they gave stronger images on blue sensitive plates than on red. When a pair of plates was blinked, the difference between blue and red stars was obvious.

Malmquist (1927, 1936) used two series-image plates (one in blue and the other in red) to determine colours of bright stars and he divided the stars into groups according to their colours. In this way he separated the stars with colour class $0.00 \leq c \leq 0.24$ (blue stars) from the others.

Iriarte, Chavira and Haro at Tonantzintla used the three-image method to detect very faint blue stars. Each plate was exposed three times, being shifted slightly sideways between exposures. The three exposures were made through ultra-violet, yellow and blue filters, respectively. The exposure time for each filter was adjusted so that all three images of a normal, unreddened A5 star were equal in intensity. A red star showed a bright middle image flanked by faint ones, but a middle image of a blue star was fainter than the other two images and thus could be recognized by inspection of the plates.

1.2.3 Comparisons between different search techniques

The spectral method has advantages for deducing the spectral types of bright stars from spectral plates. The two series-image method is worthwhile for most types of bright stars because it gives colour indices and roughly estimated magnitudes

($\pm 0\overset{m}{.}2$). The three-image method provides easy inspection of faint stars. The blink method helps us in studying even fainter stars down to the limit of the plates.

By comparison the three-image method is generally better than the other methods for faint blue stars because it is more thorough than the blink method and faster than the spectral and the two series-image methods.

1.3 Findings

The area near the north galactic pole has been searched repeatedly for faint blue stars, first by Humason and Zwicky (1947), later by Luyten (1952), by Iriarte and Chavira (1957), by Cowley (1958), by Feige (1958), by Chavira (1959) and again by Luyten (1961, 1966a). As a result, more than 3300 faint blue stars have been found and the search is complete down to $18\overset{m}{.}0$ as pointed out by Luyten in 1966.

Near the south galactic pole more than 10500 stars have been found, of these more than 1300 stars by Luyten (1954, 1966b), 419 stars by Chavira (1958), 27 stars by Cowley (1958), 42 stars by Feige (1958) and 8746 stars by Haro and Luyten (1962). It has been found (Luyten, 1966b) that the frequency function of apparent magnitude increases to a maximum at $18^{m}.5$.

According to Luyten's results, many faint blue stars are members of the galactic halo and many are extra-galactic objects.

In the far southern hemisphere (near the south polar cap), 929 faint blue stars were found by Luyten and Anderson (1958, 1959, 1967) down to a limiting magnitude of $16^{m}.5$. The observations around the south polar cap are not as complete as those close to the north and south galactic poles.

The region of the Hyades cluster has been searched repeatedly for faint blue stars, first by Humason and Zwicky (1947), later by Luyten (1954, 1956, 1957). As a result more than 300 faint blue stars have been found.

CHAPTER II

OBSERVATIONS

2.1 Search Areas

2.1.1 Introduction

In 1965 Dr. B.E. Westerlund, Dr. C. Roslund and Mr. E.B. Newell initiated a search for quasi-stellar galaxies and hot, subluminous halo stars using U, B plates from the Schmidt telescope of the Uppsala Southern Station. The plates were to cover the area between 19^h and 7^h in R.A., south of -45° Dec. In 1966 Dr. G. Lyngå and the writer joined in this programme and the present thesis was planned.

2.1.2 Present search areas

As the search area was rather large, two fields were selected, one at intermediate galactic latitudes (near the south celestial pole) and the other at high galactic latitudes. These fields which were searched for faint violet stars are defined in Tables 2.1 and 2.2 and are also displayed in Figure 2.1, in which underlined figures refer to galactic coordinates and other figures to equaterial coordinates.

Table 2.1

Limits of the intermediate galactic latitude area:

Right Ascension	19^h and 24^h
Declination	south of - $70\overset{\circ}{.}4$
Galactic longitude	305^o and 325^o
Galactic latitude	- 28^o and - 45^o

Total area : 263 square degrees.

Table 2.2

Limits of the high galactic latitude area:

Right Ascension	0^h and $2^h\ 30^m$
Declination	-45° and $-58.^\circ 2$
Galactic longitude	265° and 325°
Galactic latitude	-60° and -70°

Total area : 277 square degrees.

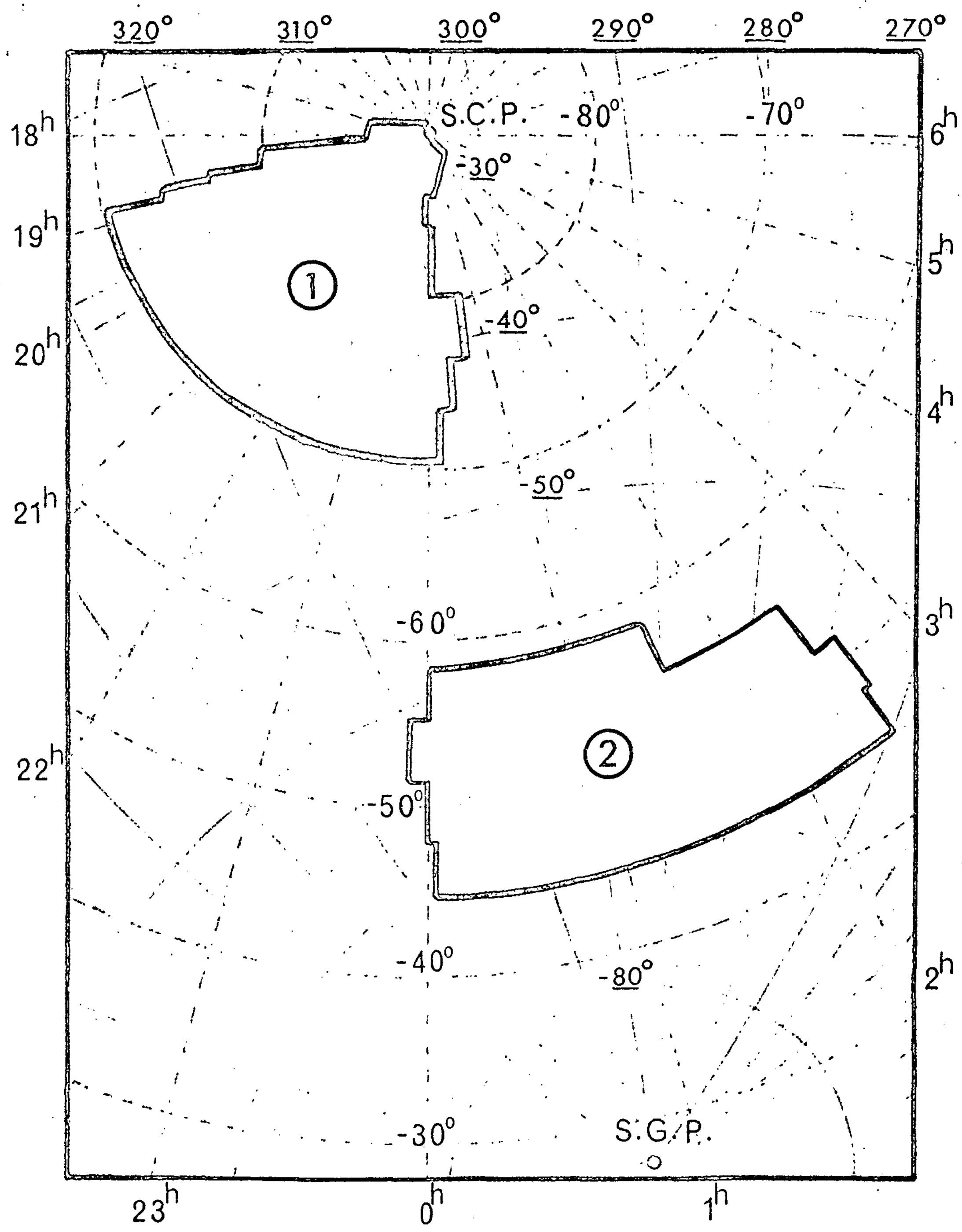


Figure 2.1

The two search areas: (1) near the south celestial pole (2) near the south galactic pole.

2.2 Photographic Observations

2.2.1 List of plates taken

The following is a list of centres for the plates taken:

Intermediate galactic latitude field

No.	Right Ascension (1965)		Declination
1	19^h	$16^m_.7$	$-72^\circ_.2$
2	19	54.8	- 72.2
3	20	33.0	- 72.2
4	21	11.1	- 72.2
5	21	49.3	- 72.2
6	22	27.4	- 72.2
7	23	05.6	- 72.2
8	23	43.7	- 72.2
9	19	15.9	- 75.4
10	20	01.8	- 75.4
11	20	47.7	- 75.4
12	21	33.6	- 75.4
13	22	19.4	- 75.4
14	23	05.3	- 75.4
15	23	51.2	- 75.4
16	19	18.7	- 78.6
17	20	15.6	- 78.6
18	21	12.5	- 78.6
19	22	09.3	- 78.6
20	23	06.2	- 78.6
21	0	03.1	- 78.6
22	19	21.6	- 81.8
23	20	37.8	- 81.8
24	21	52.0	- 81.8
25	23	07.2	- 81.8

No.	Right Ascension (1965)		Declination
26	19^h	$25^m.8$	$-85^\circ.0$
27	21	17.2	- 85.0
28	23	08.6	- 85.0
29	19	36.2	- 88.2
30	23	12.1	- 88.2

High galactic latitude field

No.	Right Ascension (1965)		Declination
31	0^h	$14^m.7$	$-46^\circ.6$
32	0	32.9	- 46.6
33	0	51.0	- 46.6
34	1	09.0	- 46.6
35	1	27.2	- 46.6
36	1	45.3	- 46.6
37	2	03.4	- 46.6
38	2	21.5	- 46.6
39	0	12.0	- 49.8
40	0	31.2	- 49.8
41	0	50.4	- 49.8
42	1	09.6	- 49.8
43	1	28.8	- 49.8
44	1	48.0	- 49.8
45	2	07.2	- 49.8
46	2	26.4	- 49.8
47	0	08.7	- 53.0
48	0	29.2	- 53.0
49	0	49.7	- 53.0
50	1	10.3	- 53.0
51	1	30.8	- 53.0
52	1	51.3	- 53.0
53	2	11.8	- 53.0
54	0	15.8	- 56.2
55	0	37.9	- 56.2
56	1	00.0	- 56.2
57	1	22.1	- 56.2

2.2.2 The U, B plates

Fifty-seven 103a-O plates (with centres listed in section 2.2.1) were taken with the 50/65/175 cm. Uppsala Schmidt telescope, 19 by Dr. G. Lyngå, 4 by Mr. E.B. Newell and the remaining 34 by the author. 30 plates covered the area near the south celestial pole and the others covered the area near the south galactic pole. The scale of the plates is 2 min. of arc per mm. and the size of the field 3.5 x 3.5 degrees. One ultra-violet and one blue image were placed side by side with a distance of about 80 microns. A 6 minute exposure was taken through Schott blue filter (GG13) and a 16 minute exposure through ultra-violet filter (UG2). The plates were taken when seeing was good to excellent to obtain the best result possible. However, there is inevitably a difference in the quality of the images from plate to plate.

With the exposure times used, a 15th magnitude star with U - B = $-1^{m}.0$ has images approximately equal in intensity. For faint stars the critical U - B is less negative than for bright ones because the calibration curve for B is steeper than that for U so the criterion of selection used for the faint stars is different from that for the bright stars. This effect was dealt with by iris photometer examinations as described in section 2.2.5.

To determine the critical (U - B) value as a function of magnitude, calibration curves for B and U were derived on the basis of photoelectric results of 25 stars in SA 205 determined by Elvius and Lyngå (1965), by Lyngå (unpublished) and by Bok (unpublished). The calibration curves are reproduced in Figure 2.2, from which the effect can be studied. If the search criterion is calibrated in such a way that a star with $B = 15^m$ has $U - B = -1^m\!.0$ when the two images are equal, then the critical U - B is $-0^m\!.91$ for $B = 16^m$ and $1^m\!.09$ for $B = 14^m$. The photoelectric data for SA 205 do not permit a study of this effect for fainter stars.

Our final selection which is based on iris photometer studies should be free of bias from this magnitude effect.

The U, B plates covering the two areas were taken with the aim of finding faint violet objects which would include very early main-sequence stars (earlier than B3), hot subdwarfs (O - B), white dwarfs and quasi-stellar objects, but the selection criterion should exclude horizontal branch stars and subdwarfs (F - G).

In addition to this programme another four plates were centred on known radio sources. Two of these, with the same exposure times as above, were centred on radio sources PKS 1754-59 and 1814-63, while the other two plates taken with exposure times of 15 minutes (through GG13) and 50 minutes (through UG2), centred on radio sources PKS 0013-63 and 0210-62.

2.2.3 The B, I plates

Sandage (1965) has suggested that two-colour plates in red and near infra-red could be used for detecting abnormal colours of quasi-stellar galaxies. Braccesi (1967) noted that quasi-stellar galaxies showed very much stronger infra-red images than ordinary blue stars on I-N plates. The author decided to use this method to distinguish between quasi-stellar galaxies and white dwarfs among the faint violet stars observed. Eight I-N plates, (Nos. 1, 2, 3, 4, 7, 24, 29 & 39), which were sensitized for 3 minutes either in

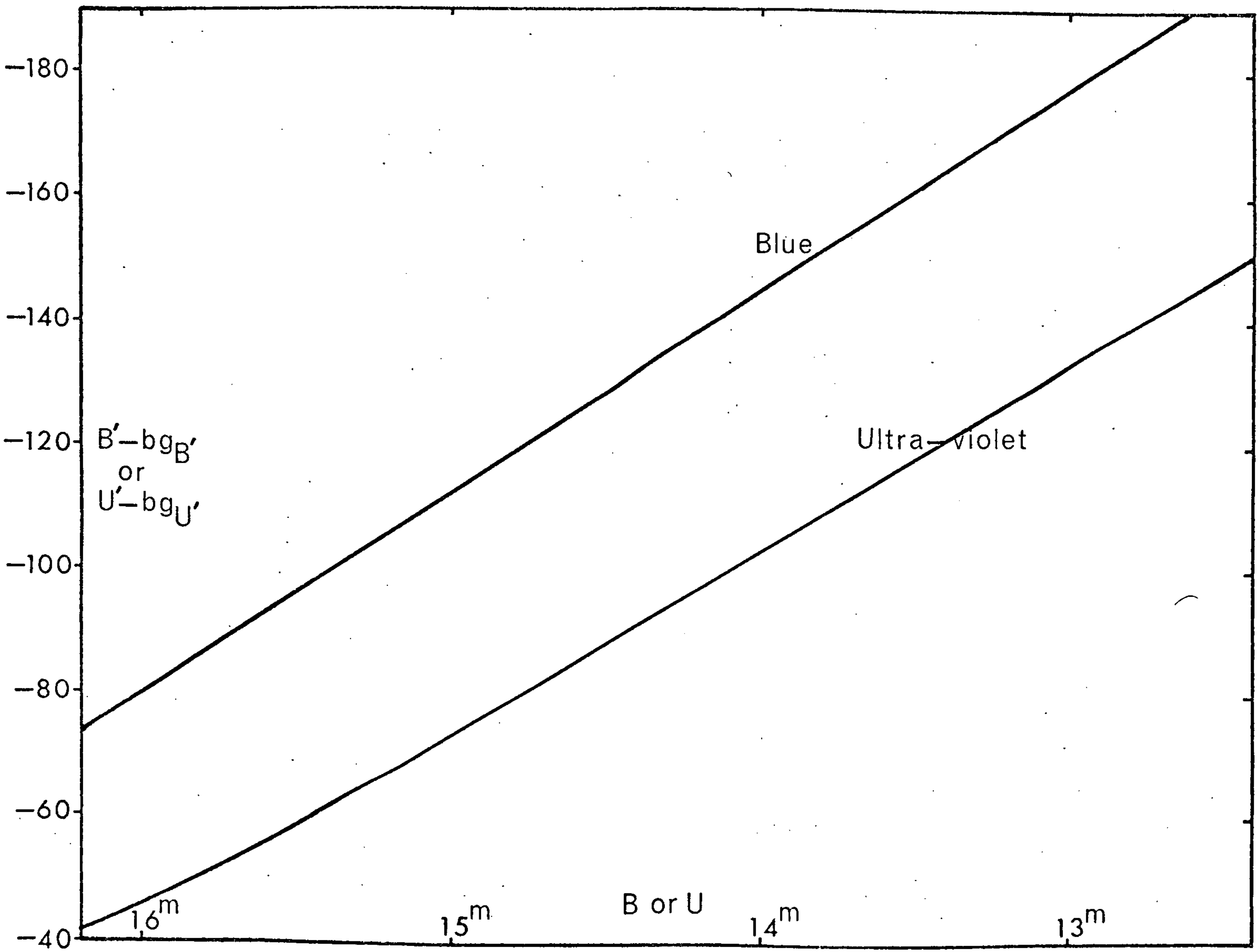


Figure 2.2 A calibration curve for B is steeper than that for U.

water or 0.6% ammonia solution (2 parts of 28 percent ammonia diluted with 100 parts of water) at a temperature of about 40°F, were taken with the 50/65/175 cm. Schmidt telescope by the writer. The plates were exposed for one hour through Schott RG-5 (infra-red) then displaced approximately 160 microns and exposed for one hour through the BG12 (blue) filter. The B, I plates covered the positions of 69 violet stars; but only 49 blue and 29 infra-red images of the 69 violet stars could be seen and only seven violet stars (Nos. 43, 76, 86, 95, 101, 150 & 170 which are all brighter than $15^{m}.0$) had blue and infra-red images of almost the same intensity. Of these seven violet stars, six have been classified as possibly violet stars and one of these was among two stars observed spectroscopically by Dr. L. Searle with the 74-inch Reflector at Mt. Stromlo Observatory. These two stars, Nos. 26 and 43, were found not to be quasars.

To sensitize I-N plates it was found that after bathing the I-N plates for 3 minutes in a dilute (0.6%) ammonia solution, the plates should be bathed for 2 or 3 minutes in water rather than in methyl or ethyl alcohol as suggested in "Kodak Plates and Films for Science and Industry, 1967, p. 21". This gives an estimated gain of another 0.5 magnitudes and the sensitivity of the emulsions also increases as the brightness of sources decreases. Sensitized in this way two other I-N plates (centred on Nos. 17 and 45) were taken with exposure times of one and a half hours (through RG5 filter) and 30 minutes (through BG12 filter). It was found that star No. 41 is stronger in infra-red than would be expected from its appearance on the U, B plate.

With the exposure times used the infra-red images of most red stars are stronger than the blue ones; for violet stars, however, the reverse is true. According to this criterion 30 violet stars (Nos. 1, 6, 9, 26, 30, 33, 36, 37, 44, 53, 54, 59, 76, 82, 91, 106, 117, 119, 134, 135, 142, 156, 160, 161, 163, 170, 208, 279, 285 & 286) are not expected to be quasi-stellar galaxies. Of these, 15 were measured photoelectrically (12 in UBVR' and 3 in UBV). None appears to be strong in the red colour R'. Star No. 41 is the only definitely violet star with infra-red image stronger than blue image. If our estimate (Section 4.4) is correct we would, in fact, expect just one QSG among

31 violet stars.

2.2.4 The direct plates

One source of error in the scanning is that two separate stars may be so placed that they appear to be two images of the same star. To detect and exclude such spurious entries in the catalogue, direct plates of all violet stars in the catalogue were taken with the same telescope as used for the U, B plates. 103a-E, 103a-D and 103a-F plates were taken with exposure times of 15, 15 and 30 minutes, respectively. These plates were also used for the finding charts of section 2.2.7.

2.2.5 The method of scanning the U, B plates

With the exposure times used the ultra-violet images of most stars are weaker than the blue ones, and images equal in intensity are obtained only for stars with strong ultra-violet radiation.

In this search for faint violet stars, U, B plates were at first examined through a microscope.

Each plate was scanned at least twice to make sure that all of the violet stars appearing on the plates were recorded. The first scanning of each plate took at least one hour. The plates were examined more carefully the second time in order to find additional faint violet stars. Stars with ultra-violet images slightly fainter than blue ones were temporarily marked. It took at least two and half hours to scan each plate the second time. All plates (while being scanned) were placed so that the blue image of each pair was above the ultra-violet image; this scanning method was used throughout, and every marked star was checked afterwards with the plate turned through an angle of 90°.

All marked images on the plates were re-examined with an Iris photometer. Images of about 100 other stars were also measured. By plotting the difference in value between the ultra-violet and the blue images ($U' - B'$), against the difference in value between the blue images and the backgrounds ($B' - bg$), violet stars could be recognized very easily because they stood out clearly from the others (see Figure 2.3). Those violet stars accepted already during the scanning

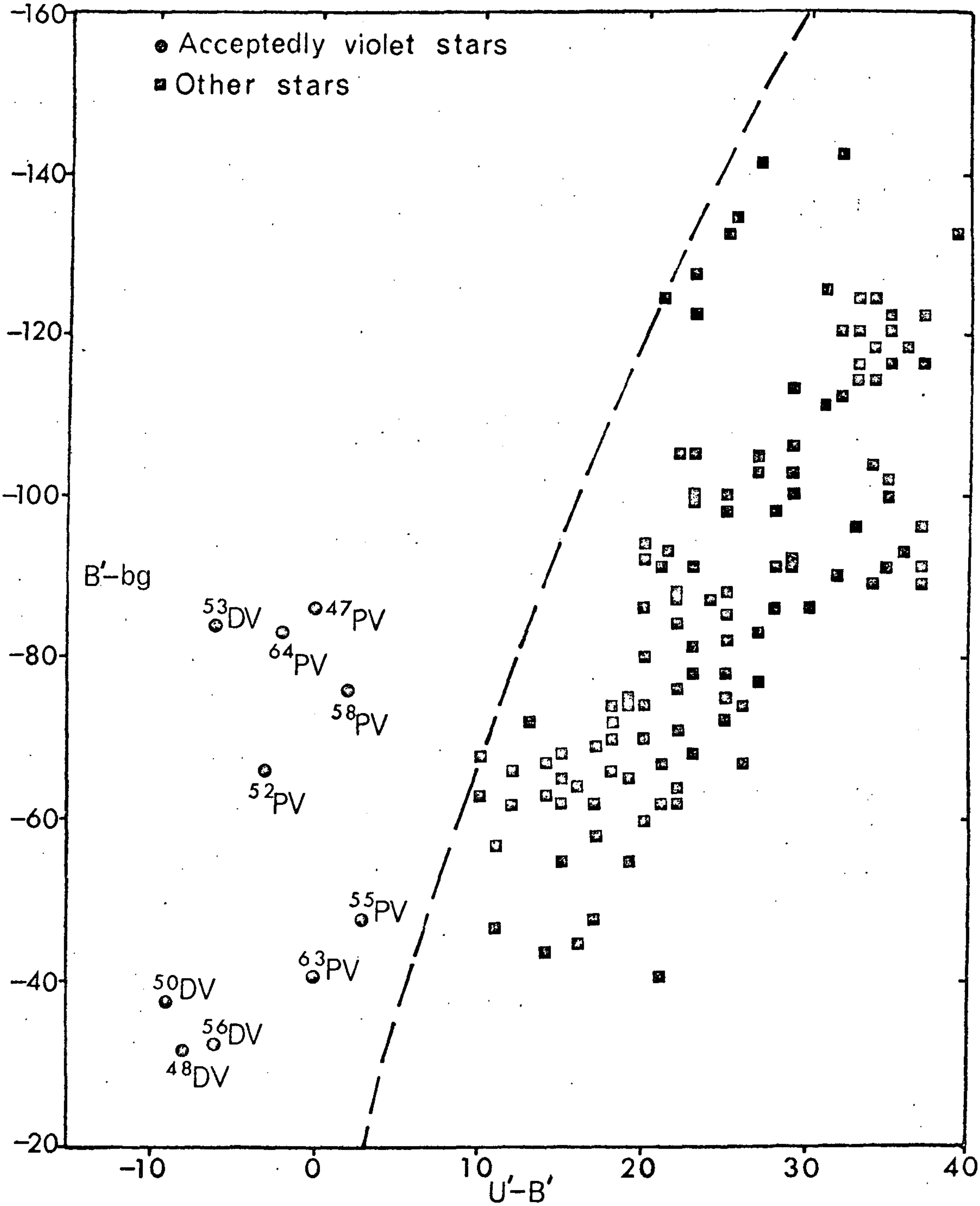


Figure 2.3 An example of the selection for violet stars using the Iris Photometer.

were called definitely violet (colour class DV) and those accepted only after iris photometer judgement were called possibly violet (colour class PV). The stars were also classified into bright (Br), intermediate (I) and faint (F).

2.2.6 Table of the violet stars

The following is a table of the 296 violet stars (169 definitely violet and 127 possibly violet) found in the two search areas.

Table 2.3

Column 1.- Catalogue number.

Column 2.- Right ascension in hours and minutes (epoch 1950.0).

Column 3.- Declination in degrees and minutes (epoch 1950.0).

Column 4.- Precession in right ascension (in minutes of time) and in declination (in minutes of arc) for 25 years.

Column 5.- Galactic longitude (l^{II}) and latitude (b^{II})

in degrees.

Column 6.- Ultra-violet classification☆,

Where DV = Definitely violet,

PV = Possibly violet.

Column 7.- Brightness classification☆☆,

where Br = Bright (approximately $B_{Br} < 14^m$),

I = Intermediate (approximately $14^m \leq B_I \leq 16^m$),

F = Faint (approximately $B_F > 16^m$).

Column 8.- Previous catalogue number.

LB refers to Luyten and Anderson (1958, 1959)

L refers to Luyten and Smith (1958)

Column 9.- Photoelectric observations from which results are given in Table 2.6.

☆Mean (U - B) for DV = $- 0^m.92$ (37 stars)

Mean (U - B) for PV = $- 0^m.69$ (3 stars)

☆☆Mean (B) for Br = $13^m.08$ (12 stars)

Mean (B) for I = $15^m.00$ (16 stars)

Mean (B) for F = $16^m.79$ (15 stars)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1	17 8.5	-87 7	12.4 -1	305.90-26.15	PV	I	-	UBVR'
2	17 50.1	-87 26	13.6 1	305.78-26.72	DV	F	-	UBV
3	18 33.7	-83 16	5.9 2	310.52-26.75	PV	F	-	-
4	18 35.5	-88 57	26.9 3	304.18-27.33	PV	I	-	-
5	18 53.6	-85 25	7.8 3	308.17-27.40	DV	F	-	-
6	18 54.8	-70 38	2.8 2	324.69-26.21	DV	Br	-	UBVR'
7	18 55.7	-75 51	3.4 2	318.90-26.91	PV	I	-	-
8	18 56.2	-76 23	3.5 2	318.32-26.99	DV	F	-	-
9	19 2.4	-72 35	3.0 3	322.59-27.04	DV	Br	-	UBVR'
10	19 2.8	-82 19	5.2 3	311.66-27.59	PV	F	-	-
11	19 5.0	-72 27	3.0 3	322.78-27.22	DV	F	-	UBV
12	19 5.5	-72 22	2.9 3	322.88-27.25	PV	I	-	-
13	19 6.8	-71 15	2.8 3	324.14-27.25	DV	I	-	UBVR'
14	19 10.3	-76 15	3.4 3	318.52-27.81	PV	F	-	-
15	19 10.6	-72 49	3.0 3	322.39-27.67	DV	F	-	UBV
16	19 12.4	-83 59	6.1 3	309.77-27.85	PV	F	-	-
17	19 14.5	-82 47	5.3 3	311.13-27.97	PV	F	-	-
18	19 17.5	-71 42	2.9 3	323.70-28.13	DV	F	-	-
19	19 17.5	-86 46	10.0 3	306.63-27.75	PV	F	-	-
20	19 20.7	-70 46	2.8 3	324.76-28.35	PV	I	-	-
21	19 21.7	-70 54	2.8 3	324.61-28.44	PV	I	-	-
22	19 27.5	-74 39	3.1 3	320.33-28.89	PV	Br	-	-
23	19 28.3	-77 52	3.6 3	316.68-28.80	DV	F	-	UBV
24	19 28.6	-76 55	3.5 3	317.76-28.87	PV	I	-	-
25	19 33.0	-76 8	3.3 4	318.63-29.17	DV	Br	-	UBVR'
26	19 41.6	-78 3	3.6 4	316.40-29.47	DV	I	-	UBVR'
27	19 43.1	-84 44	6.4 4	308.83-28.51	PV	I	-	-
28	19 44.0	-83 29	5.5 4	310.23-28.76	PV	I	LB 3122	-
29	19 45.8	-78 32	3.7 4	315.80-29.62	DV	F	-	UBV
30	19 46.8	-77 1	3.4 4	317.54-29.88	PV	I	-	-
31	19 46.8	-70 48	2.7 4	324.68-30.49	DV	F	-	-
32	19 49.6	-75 25	3.1 4	319.34-30.25	DV	F	-	-
33	19 53.1	-71 32	2.7 4	323.79-30.94	DV	I	L 80-56	UBVR'
34	19 53.4	-81 26	4.4 4	312.46-29.46	PV	F	-	-
35	19 53.5	-83 21	5.3 4	310.30-29.05	PV	F	-	-

(1)	(2)	(3)	(4)		(5)	(6)	(7)	(8)	(9)
36	19 56.3	-72 6	2.8	4	323.10-31.12	DV	Br	-	UBVR'
37	19 58.8	-73 7	2.8	4	321.89-31.17	DV	I	-	UBVR'
38	20 2.2	-74 32	3.0	4	320.22-31.19	PV	F	-	-
39	20 3.0	-77 30	3.4	5	316.81-30.68	DV	I	-	-
40	20 3.6	-71 11	2.7	5	324.07-31.81	PV	F	-	-
41	20 4.9	-78 1	3.5	5	316.20-30.67	DV	F	-	-
42	20 5.5	-73 45	2.9	5	321.08-31.55	DV	F	-	UBV
43	20 6.4	-71 24	2.7	5	323.78-32.00	PV	I	-	UBVR'
44	20 6.7	-73 25	2.8	5	321.44-31.69	PV	I	-	-
45	20 6.7	-74 8	2.9	5	320.62-31.56	DV	F	-	-
46	20 11.2	-81 2	4.1	5	312.73-30.21	DV	F	-	-
47	20 11.4	-73 14	2.8	5	321.57-32.06	PV	I	-	-
48	20 13.3	-72 58	2.8	5	321.85-32.25	DV	F	-	UBVR'
49	20 14.9	-74 6	2.9	5	320.51-32.11	PV	F	-	-
50	20 16.5	-73 31	2.8	5	321.17-32.35	DV	F	-	-
51	20 18.3	-80 31	3.9	5	313.19-30.62	DV	F	-	-
52	20 26.0	-72 42	2.7	5	321.90-33.21	PV	F	-	-
53	20 26.1	-73 51	2.8	5	320.59-32.93	DV	I	-	UBVR'
54	20 28.6	-77 52	3.3	5	315.97-31.90	DV	F	-	-
55	20 28.6	-71 41	2.6	5	323.04-33.67	PV	F	-	-
56	20 29.5	-71 56	2.6	5	322.72-33.67	DV	F	-	-
57	20 37.0	-78 19	3.3	6	315.30-32.16	DV	F	-	-
58	20 37.1	-72 8	2.6	5	322.29-34.18	PV	I	-	-
59	20 37.7	-78 53	3.4	6	314.67-31.99	DV	F	-	-
60	20 40.0	-80 42	3.8	6	312.65-31.40	DV	F	-	-
61	20 41.0	-83 51	5.0	6	309.28-30.15	DV	F	-	-
62	20 41.9	-75 35	2.9	6	318.23-33.39	PV	Br	-	-
63	20 43.7	-73 2	2.6	6	321.07-34.37	PV	F	-	-
64	20 44.2	-72 19	2.6	6	321.88-34.64	PV	I	-	-
65	20 45.3	-75 50	2.9	6	317.87-33.50	PV	F	-	-
66	20 56.3	-76 8	2.8	6	317.21-33.98	PV	F	-	-
67	20 56.3	-77 45	3.1	6	315.45-33.30	PV	F	-	-
68	20 56.7	-74 28	2.7	6	319.05-34.69	PV	F	-	-
69	20 57.7	-73 23	2.6	6	320.23-35.19	PV	F	-	-
70	21 2.2	-73 31	2.6	6	319.92-35.43	PV	F	-	-

(1)	(2)		(3)		(4)		(5)	(6)	(7)	(8)	(9)
71	21	4.1	-73	58	2.6	6	319.34-35.35	PV	F	-	-
72	21	4.8	-77	11	2.9	6	315.81-33.96	DV	F	-	-
73	21	5.4	-82	1	3.9	6	310.76-31.65	PV	I	L 24-52	-
74	21	10.6	-77	10	2.9	6	315.64-34.26	PV	F	-	-
75	21	14.0	-77	59	2.9	6	314.69-34.01	PV	F	-	-
76	21	23.1	-82	54	3.9	7	309.52-31.67	PV	Br	-	-
77	21	24.4	-71	12	2.3	7	321.56-37.96	PV	F	-	-
78	21	24.4	-72	52	2.4	7	319.72-37.15	DV	F	-	-
79	21	24.7	-77	37	2.8	7	314.70-34.69	DV	F	-	-
80	21	26.7	-71	22	2.3	7	321.27-38.04	DV	F	-	-
81	21	31.3	-76	18	2.6	7	315.80-35.72	DV	F	-	-
82	21	31.4	-73	2	2.3	7	319.22-37.50	DV	Br	-	-
83	21	33.7	-80	49	3.2	7	311.25-33.20	DV	F	-	-
84	21	34.8	-79	56	3.0	7	312.07-33.77	DV	F	-	-
85	21	38.2	-75	38	2.5	7	316.19-36.45	DV	F	-	-
86	21	42.3	-81	28	3.2	7	310.40-33.06	PV	Br	-	-
87	21	43.5	-76	35	2.5	7	315.01-36.14	PV	Br	-	-
88	21	47.2	-84	8	4.0	7	307.90-31.43	DV	F	-	-
89	21	47.5	-72	55	2.2	7	318.51-38.55	DV	F	-	-
90	21	49.1	-76	11	2.5	7	315.14-36.65	DV	F	-	-
91	21	49.5	-88	13	8.7	7	304.43-28.66	DV	F	-	-
92	21	51.1	-70	52	2.1	7	320.44-39.97	PV	I	-	-
93	21	51.5	-70	49	2.1	7	320.46-40.02	DV	F	-	-
94	21	57.1	-76	7	2.4	7	314.83-37.06	PV	I	-	-
95	21	58.4	-80	52	2.9	7	310.45-33.92	PV	Br	-	-
96	21	59.0	-73	53	2.2	7	316.88-38.60	DV	I	-	UBVR'
97	21	59.8	-75	28	2.3	7	315.31-37.61	PV	I	L 48-15	-
98	22	.9	-82	36	3.2	7	308.89-32.78	DV	F	-	-
99	22	7.5	-76	41	2.3	7	313.79-37.13	DV	I	-	UBVR'
100	22	11.7	-81	4	2.8	8	309.83-34.15	DV	F	-	-
101	22	13.0	-81	14	2.8	8	309.65-34.06	DV	Br	-	-
102	22	13.8	-85	10	3.9	8	306.54-31.13	DV	F	-	-
103	22	17.2	-71	2	2.0	8	318.49-41.51	PV	F	-	-
104	22	21.8	-70	52	1.9	8	318.29-41.89	DV	F	-	-
105	22	23.4	-71	19	1.9	8	317.73-41.67	PV	F	-	-

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
106	22 24.0	-82 0	2.8 8	308.68-33.74	DV	I	-	-
107	22 26.9	-72 1	1.9 8	316.82-41.36	DV	F	-	-
108	22 28.0	-84 50	3.4 8	306.49-31.57	PV	F	-	-
109	22 31.0	-79 53	2.4 8	310.02-35.56	DV	F	-	-
110	22 32.9	-78 43	2.3 8	310.83-36.53	DV	F	-	-
111	22 34.1	-77 8	2.1 8	312.00-37.81	DV	Br	-	UBVR'
112	22 34.4	-77 40	2.2 8	311.57-37.41	DV	F	-	-
113	22 39.1	-72 16	1.9 8	315.68-41.80	PV	F	-	-
114	22 41.2	-80 46	2.3 8	308.95-35.10	PV	F	-	-
115	22 41.4	-75 8	1.9 8	313.14-39.65	DV	F	-	-
116	22 44.6	-73 50	1.9 8	313.96-40.82	DV	F	-	-
117	22 51.1	-72 39	1.8 8	314.40-42.04	DV	I	-	UBVR'
118	22 56.2	-74 21	1.8 8	312.70-40.86	DV	F	-	-
119	22 59.2	-71 29	1.7 8	314.61-43.36	DV	Br	-	UBVR'
120	23 .7	-71 55	1.7 8	314.15-43.07	DV	F	-	-
121	23 1.7	-83 8	2.3 8	306.71-33.47	PV	F	-	-
122	23 2.3	-71 19	1.7 8	314.45-43.63	DV	F	-	UBV
123	23 2.9	-77 37	1.9 8	310.00-38.30	PV	I	-	-
124	23 3.0	-78 9	1.9 8	309.66-37.84	PV	Br	-	-
125	23 3.4	-71 31	1.7 8	314.22-43.52	DV	F	-	UBV
126	23 3.8	-75 17	1.8 8	311.49-40.33	PV	Br	-	-
127	23 7.1	-81 1	2.0 8	307.73-35.43	PV	F	-	-
128	23 7.2	-86 45	3.1 8	304.62-30.33	PV	I	-	-
129	23 11.4	-83 10	2.1 8	306.38-33.59	PV	Br	-	-
130	23 12.0	-74 48	1.7 8	311.21-41.02	PV	Br	-	-
131	23 13.2	-75 18	1.7 8	310.80-40.62	DV	F	-	-
132	23 13.9	-76 13	1.7 8	310.19-39.83	DV	F	-	-
133	23 15.5	-71 7	1.6 8	313.34-44.36	DV	F	-	UBV
134	23 18.8	-70 43	1.5 8	313.29-44.84	DV	I	-	UBVR'
135	23 22.9	-71 44	1.5 8	312.22-44.10	PV	I	-	-
136	23 23.4	-79 32	1.7 8	307.77-37.07	PV	F	-	-
137	23 26.5	-75 29	1.6 8	309.70-40.83	DV	F	-	-
138	23 29.4	-88 14	3.0 8	303.68-29.05	PV	F	-	-
139	23 31.6	-71 31	1.5 8	311.49-44.59	DV	F	-	-
140	23 33.0	-70 59	1.5 8	311.65-45.12	PV	F	-	-

(1)	(2)	(3)	(4)		(5)	(6)	(7)	(8)	(9)
141	23 34.9	-80 21	1.6	8	306.79-36.50	PV	I	-	-
142	23 37.9	-88 40	2.7	8	303.47-28.67	PV	I	-	-
143	23 40.0	-80 23	1.5	8	306.53-36.53	PV	I	-	-
144	23 45.7	-73 23	1.4	8	309.15-43.25	DV	F	-	-
145	23 49.7	-72 30	1.3	8	309.16-44.19	PV	F	-	-
146	23 52.8	-72 32	1.3	8	308.83-44.22	DV	F	-	-
147	23 52.8	-75 47	1.3	8	307.54-41.11	PV	F	-	-
148	23 54.8	-87 3	1.5	8	303.80-30.26	PV	I	-	-
149	23 58.0	-75 41	1.3	8	307.16-41.30	PV	F	-	-
150	0 .4	-49 11	1.3	8	323.01-66.30	DV	Br	-	UBVR'
151	0 .5	-71 20	1.3	8	308.50-45.54	DV	F	-	-
152	0 1.2	-48 56	1.3	8	322.99-66.57	DV	F	-	-
153	0 1.9	-54 11	1.3	8	317.67-61.86	PV	F	-	-
154	0 2.0	-71 3	1.3	8	308.44-45.84	DV	F	-	-
155	0 3.1	-57 1	1.3	8	315.23-59.28	PV	I	-	-
156	0 3.2	-50 23	1.3	8	320.72-65.41	PV	F	-	-
157	0 3.6	-50 26	1.3	8	320.52-65.39	DV	F	-	-
158	0 4.2	-54 4	1.3	8	317.11-62.10	PV	F	-	-
159	0 4.7	-86 31	1.0	8	303.78-30.81	PV	F	-	-
160	0 5.0	-49 42	1.3	8	320.78-66.16	PV	F	-	-
161	0 5.3	-49 18	1.3	8	321.07-66.54	PV	I	-	-
162	0 6.1	-46 36	1.3	8	323.92-69.02	DV	F	-	UBV
163	0 8.0	-50 32	1.3	8	318.87-65.59	DV	Br	-	UBVR'
164	0 8.2	-48 24	1.3	8	320.93-67.56	DV	F	-	-
165	0 9.3	-50 46	1.3	8	318.21-65.45	DV	F	-	-
166	0 10.2	-46 8	1.3	8	322.72-69.76	DV	I	-	UBVR'
167	0 10.4	-53 37	1.2	8	315.56-62.84	PV	Br	-	-
168	0 11.0	-46 33	1.3	8	321.89-69.44	PV	Br	-	-
169	0 12.1	-56 49	1.2	8	313.07-59.86	DV	I	-	-
170	0 12.2	-49 9	1.2	8	318.60-67.13	PV	I	-	-
171	0 12.8	-47 16	1.2	8	320.26-68.91	DV	F	-	UBV
172	0 13.3	-78 52	1.1	8	305.19-38.38	PV	I	-	-
173	0 14.0	-45 53	1.2	8	321.25-70.25	PV	Br	-	-
174	0 15.3	-45 43	1.2	8	320.85-70.50	PV	F	-	-
175	0 15.4	-74 39	1.1	8	306.01-42.55	PV	I	-	-

(1)	(2)	(3)	(4)		(5)	(6)	(7)	(8)	(9)
176	0 15.5	-76 14	1.1	8	305.64-41.00	PV	F	-	-
177	0 18.3	-52 11	1.2	8	313.97-64.57	PV	F	-	-
178	0 18.8	-54 50	1.2	8	312.29-62.02	DV	F	-	-
179	0 19.1	-55 46	1.2	8	311.73-61.13	DV	I	-	-
180	0 19.1	-57 36	1.2	8	310.85-59.34	DV	F	-	-
181	0 19.1	-51 59	1.2	8	313.83-64.78	PV	I	L 128-28	-
182	0 21.2	-52 50	1.2	8	312.61-64.04	DV	F	-	-
183	0 21.3	-53 37	1.2	8	312.16-63.29	DV	I	-	-
184	0 23.4	-50 0	1.2	8	313.52-66.87	PV	Br	-	-
185	0 25.0	-47 42	1.2	8	314.42-69.17	DV	F	-	-
186	0 26.4	-48 47	1.2	8	313.06-68.17	DV	I	LB 1557	-
187	0 26.4	-49 23	1.2	8	312.67-67.60	PV	Br	-	-
188	0 27.1	-55 49	1.2	8	309.40-61.32	PV	Br	-	-
189	0 27.5	-54 3	1.2	8	309.97-63.06	PV	F	-	-
190	0 27.7	-77 52	1.0	8	304.45-39.47	DV	F	-	-
191	0 27.9	-46 49	1.2	8	313.69-70.15	DV	Br	LB 1558	-
192	0 28.4	-47 29	1.2	8	313.00-69.51	PV	I	-	-
193	0 29.0	-44 55	1.2	8	314.55-72.04	DV	F	-	-
194	0 29.3	-47 42	1.2	8	312.43-69.34	PV	Br	LB 1959	-
195	0 30.1	-51 17	1.2	8	310.22-65.86	DV	F	-	-
196	0 31.2	-58 2	1.2	8	307.60-59.21	PV	F	-	-
197	0 31.3	-55 25	1.2	8	308.33-61.80	DV	F	-	-
198	0 31.8	-49 22	1.2	8	310.43-67.78	PV	Br	-	-
199	0 31.8	-56 8	1.2	8	307.96-61.11	DV	F	-	-
200	0 33.1	-51 54	1.2	8	308.88-65.31	DV	F	-	-
201	0 36.4	-48 45	1.2	8	308.66-68.52	DV	F	-	-
202	0 37.9	-55 18	1.2	8	306.36-62.02	DV	Br	LB 1566	-
203	0 38.3	-51 14	1.2	8	307.13-66.08	PV	F	-	-
204	0 39.4	-79 23	.8	8	303.56-38.01	PV	F	-	-
205	0 39.9	-55 25	1.1	8	305.74-61.93	PV	F	-	-
206	0 40.0	-56 26	1.1	8	305.57-60.93	DV	F	-	-
207	0 40.2	-48 39	1.2	8	307.01-68.69	DV	F	LB 1568	-
208	0 41.4	-89 46	-6.5	8	303.01-27.63	PV	I	-	-
209	0 41.5	-51 52	1.2	8	305.78-65.49	DV	I	LB 1571	-
210	0 42.4	-52 18	1.2	8	305.41-65.06	DV	F	-	-

(1)	(2)	(3)	(4)		(5)	(6)	(7)	(8)	(9)
211	0 42.8	-55 25	1.1	8	304.88-61.97	DV	F	-	-
212	0 46.8	-56 22	1.1	8	303.62-61.03	DV	Br	-	-
213	0 46.9	-51 59	1.1	8	303.77-65.41	PV	F	-	-
214	0 48.4	-49 43	1.1	8	303.25-67.68	PV	F	-	-
215	0 49.1	-50 18	1.1	8	302.96-67.10	PV	F	-	-
216	0 49.7	-47 23	1.2	8	302.65-70.01	PV	F	-	-
217	0 53.7	-51 30	1.1	8	301.20-65.88	DV	F	-	-
218	0 56.1	-50 34	1.1	8	300.13-66.79	DV	F	-	-
219	0 56.6	-56 51	1.1	8	300.88-60.52	PV	I	-	-
220	0 58.3	-51 30	1.1	8	299.48-65.84	DV	F	-	-
221	0 58.3	-52 59	1.1	8	299.77-64.36	PV	F	-	-
222	0 59.4	-57 2	1.1	8	300.15-60.31	DV	F	-	-
223	1 1.1	-56 48	1.1	8	299.65-60.52	DV	F	-	-
224	1 1.1	-55 56	1.1	8	299.47-61.38	DV	F	-	-
225	1 3.2	-54 21	1.1	8	298.46-62.92	DV	I	-	UBVR'
226	1 3.8	-56 12	1.1	8	298.75-61.07	DV	F	-	-
227	1 3.9	-48 21	1.1	8	296.10-68.86	DV	F	-	-
228	1 4.7	-46 25	1.1	8	294.80-70.73	PV	I	L 292-41	-
229	1 5.4	-46 58	1.1	8	294.72-70.17	PV	F	-	-
230	1 7.2	-53 12	1.1	8	296.78-63.97	DV	F	L 221-49	-
231	1 8.6	-51 39	1.1	8	295.66-65.48	DV	F	-	-
232	1 9.8	-51 13	1.1	8	295.01-65.86	DV	I	LB 1595	-
233	1 10.0	-45 18	1.1	8	291.24-71.63	DV	F	-	-
234	1 10.3	-56 30	1.0	8	297.00-60.65	DV	I	-	UBVR'
235	1 10.5	-52 46	1.1	8	295.48-64.33	DV	F	-	-
236	1 12.0	-52 60	1.1	8	295.09-64.05	DV	Br	-	UBVR'
237	1 12.9	-52 24	1.1	8	294.47-64.61	DV	F	-	-
238	1 16.9	-47 26	1.1	8	289.61-69.23	DV	I	-	-
239	1 17.3	-48 4	1.1	8	289.95-68.62	DV	F	-	-
240	1 17.5	-49 27	1.1	8	290.94-67.29	DV	I	-	-
241	1 18.2	-55 34	1.0	8	294.39-61.35	DV	Br	-	-
242	1 19.6	-55 48	1.0	8	294.10-61.07	DV	Br	LB 1598	-
243	1 20.9	-48 4	1.1	8	288.41-68.42	PV	I	-	-
244	1 24.2	-50 40	1.0	8	289.33-65.80	DV	I	-	-
245	1 25.4	-50 38	1.0	8	288.87-65.77	DV	F	-	-

(1)	(2)	(3)	(4)		(5)	(6)	(7)	(8)	(9)
246	1 26.0	-53 1	1.0	8	290.49-63.47	DV	F	-	-
247	1 26.2	-53 16	1.0	8	290.61-63.24	PV	I	L 222-53	-
248	1 26.8	-54 37	1.0	8	291.34-61.92	DV	F	-	-
249	1 26.9	-51 46	1.0	8	289.26-64.62	DV	I	-	UBV
250	1 29.2	-45 45	1.1	8	282.13-69.99	PV	I	-	-
251	1 30.2	-49 49	1.0	8	286.39-66.23	PV	Br	-	-
252	1 30.6	-51 60	1.0	8	288.20-64.19	DV	F	-	-
253	1 31.4	-54 40	1.0	8	290.06-61.66	DV	I	-	-
254	1 32.1	-56 34	1.0	8	291.17-59.83	DV	F	-	-
255	1 34.2	-45 19	1.1	8	279.33-69.95	PV	F	-	-
256	1 40.0	-45 59	1.0	8	277.84-68.86	DV	I	-	UBV
257	1 40.0	-52 59	1.0	8	286.13-62.72	PV	F	-	-
258	1 41.9	-53 39	1.0	8	286.20-61.99	PV	F	-	-
259	1 42.2	-47 11	1.0	8	278.73-67.63	DV	F	-	-
260	1 42.9	-46 20	1.0	8	277.23-68.29	DV	F	-	-
261	1 45.3	-51 49	1.0	8	283.37-63.39	DV	Br	LB 3229	-
262	1 46.8	-47 37	1.0	7	277.69-66.85	DV	F	-	-
263	1 47.9	-54 4	.9	7	284.96-61.22	PV	F	-	-
264	1 49.2	-52 26	1.0	7	282.91-62.56	DV	I	-	-
265	1 52.7	-50 10	1.0	7	279.19-64.20	DV	F	-	-
266	1 52.7	-49 52	1.0	7	278.80-64.44	DV	F	-	-
267	1 53.2	-45 21	1.0	7	271.80-67.97	DV	I	-	-
268	1 54.5	-46 18	1.0	7	272.95-67.10	PV	F	-	-
269	1 55.0	-47 37	1.0	7	274.90-66.03	PV	F	-	-
270	1 55.0	-47 24	1.0	7	274.54-66.20	DV	F	-	-
271	1 55.6	-49 42	1.0	7	277.68-64.31	DV	F	-	-
272	1 57.5	-47 15	1.0	7	273.50-66.05	PV	F	-	-
273	1 58.0	-49 3	1.0	7	276.06-64.59	DV	F	-	-
274	1 58.1	-50 55	.9	7	278.57-63.08	DV	F	-	-
275	1 58.9	-55 0	.9	7	283.10-59.62	DV	F	-	-
276	1 59.6	-50 43	.9	7	277.87-63.11	PV	F	-	-
277	1 59.8	-53 58	.9	7	281.77-60.42	DV	Br	LB 3227	-
278	2 .9	-51 21	.9	7	278.34-62.48	DV	F	-	UBV
279	2 1.0	-51 30	.9	7	278.50-62.35	PV	Br	LB 3238	UBV
280	2 2.5	-51 12	.9	7	277.74-62.45	DV	F	-	-

(1)	(2)	(3)	(4)		(5)	(6)	(7)	(8)	(9)
281	2 3.2	-50 13	.9	7	276.22-63.15	DV	F	-	-
282	2 3.4	-48 48	1.0	7	274.09-64.23	DV	F	-	-
283	2 6.6	-50 44	.9	7	276.01-62.42	PV	I	-	-
284	2 8.2	-51 14	.9	7	276.27-61.87	DV	F	-	-
285	2 11.3	-49 59	.9	7	273.70-62.49	DV	Br	LB 3241	UBV
286	2 11.4	-50 19	.9	7	274.17-62.24	DV	Br	-	UBV
287	2 12.2	-53 19	.9	7	278.01-59.87	DV	F	-	-
288	2 13.9	-48 27	.9	7	270.70-63.30	DV	F	-	UBVR'
289	2 14.9	-52 30	.9	7	276.33-60.23	DV	F	-	-
290	2 19.3	-46 5	1.0	7	265.33-64.17	DV	F	-	-
291	2 20.2	-50 46	.9	7	272.69-60.94	DV	I	-	-
292	2 21.7	-50 26	.9	7	271.86-61.01	PV	F	-	-
293	2 28.2	-47 19	.9	7	265.43-62.22	PV	I	-	-
294	2 28.8	-51 41	.9	7	272.14-59.34	PV	Br	-	-
295	2 29.1	-48 9	.9	7	266.62-61.59	DV	F	LB 1628	UBV
296	2 29.7	-48 40	.9	7	267.34-61.18	DV	F	-	-

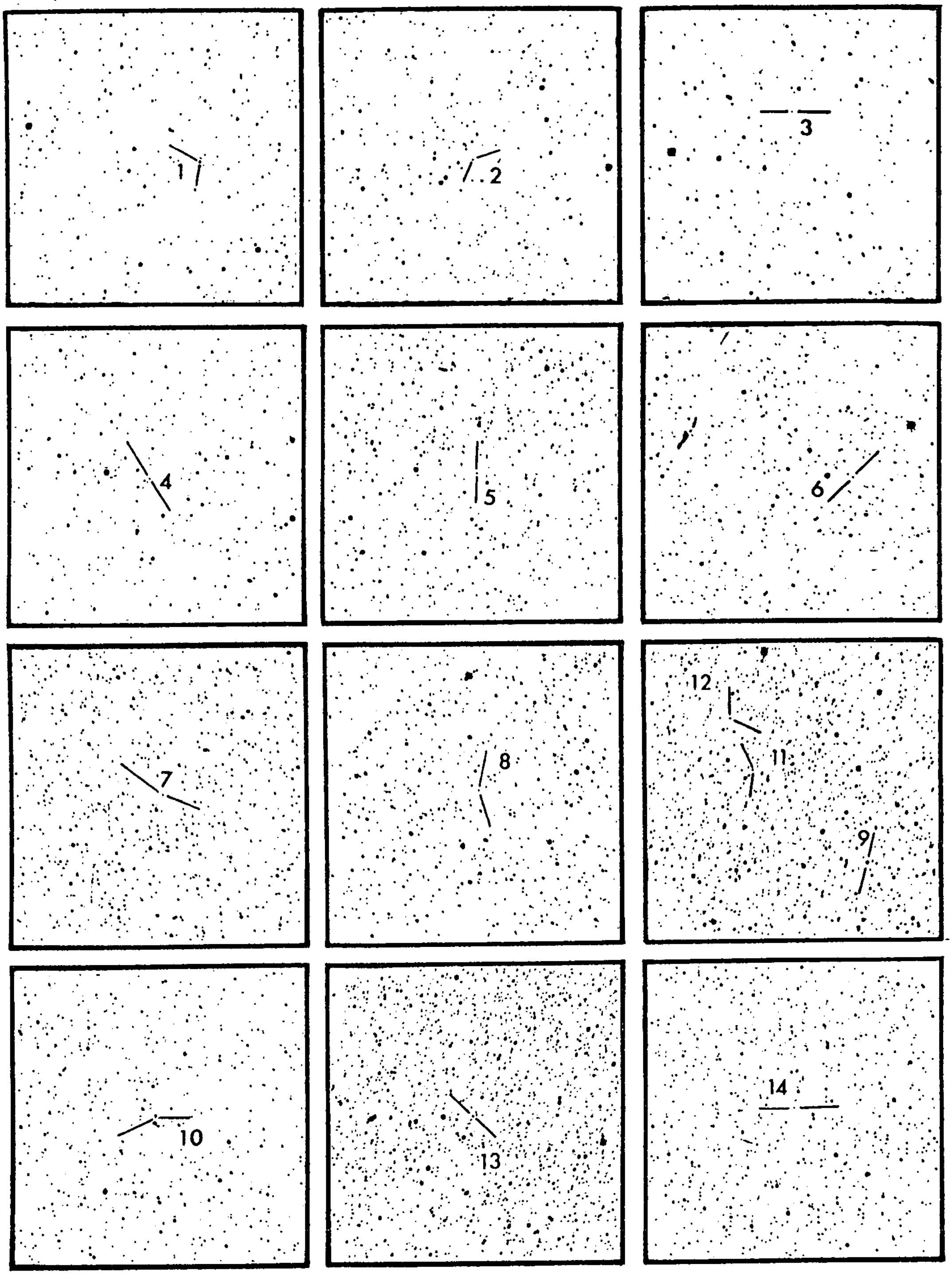
2.2.7 Finding charts of the violet stars

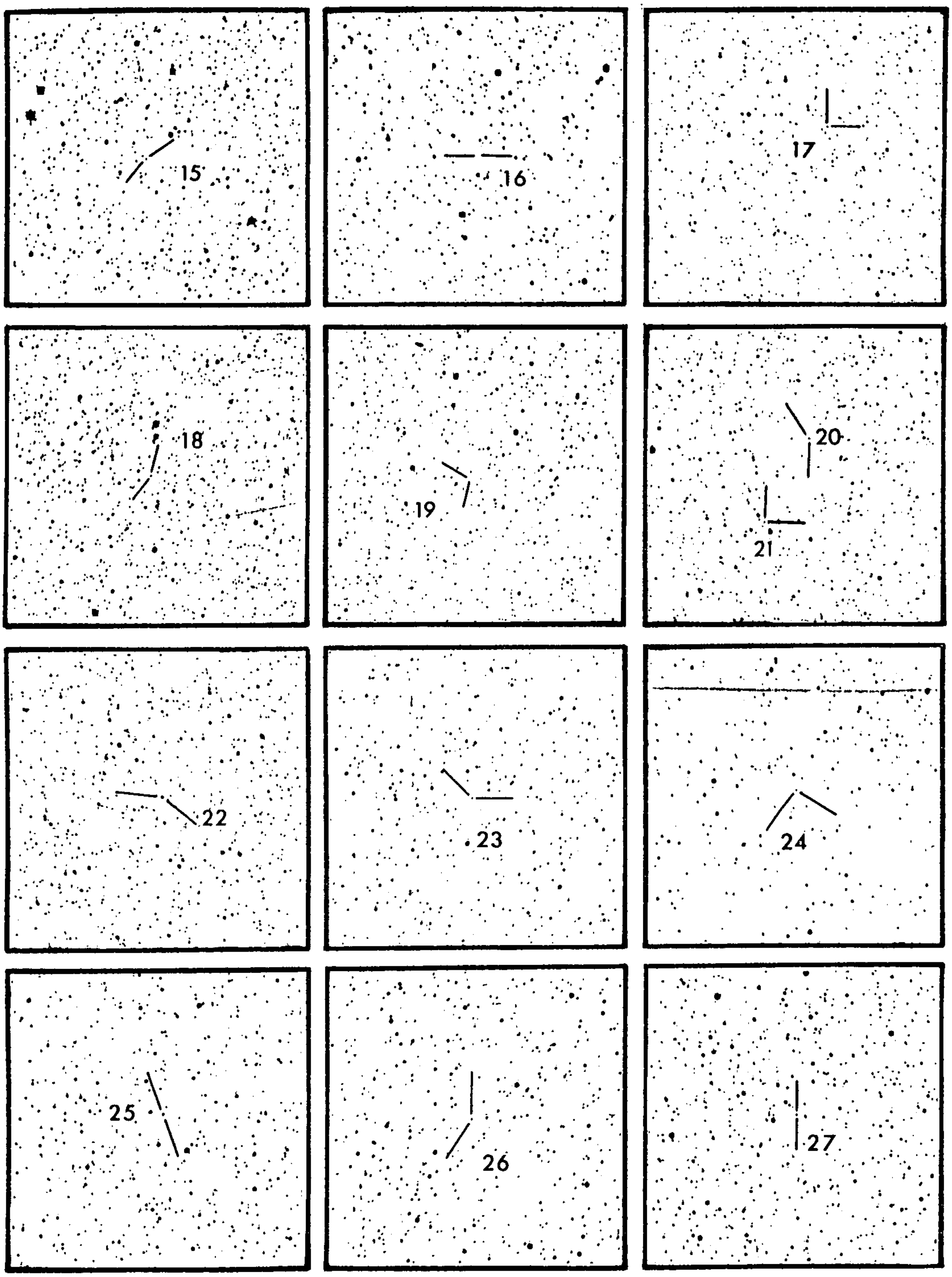
Scale : 1.5 mm. = 1 min. of arc.

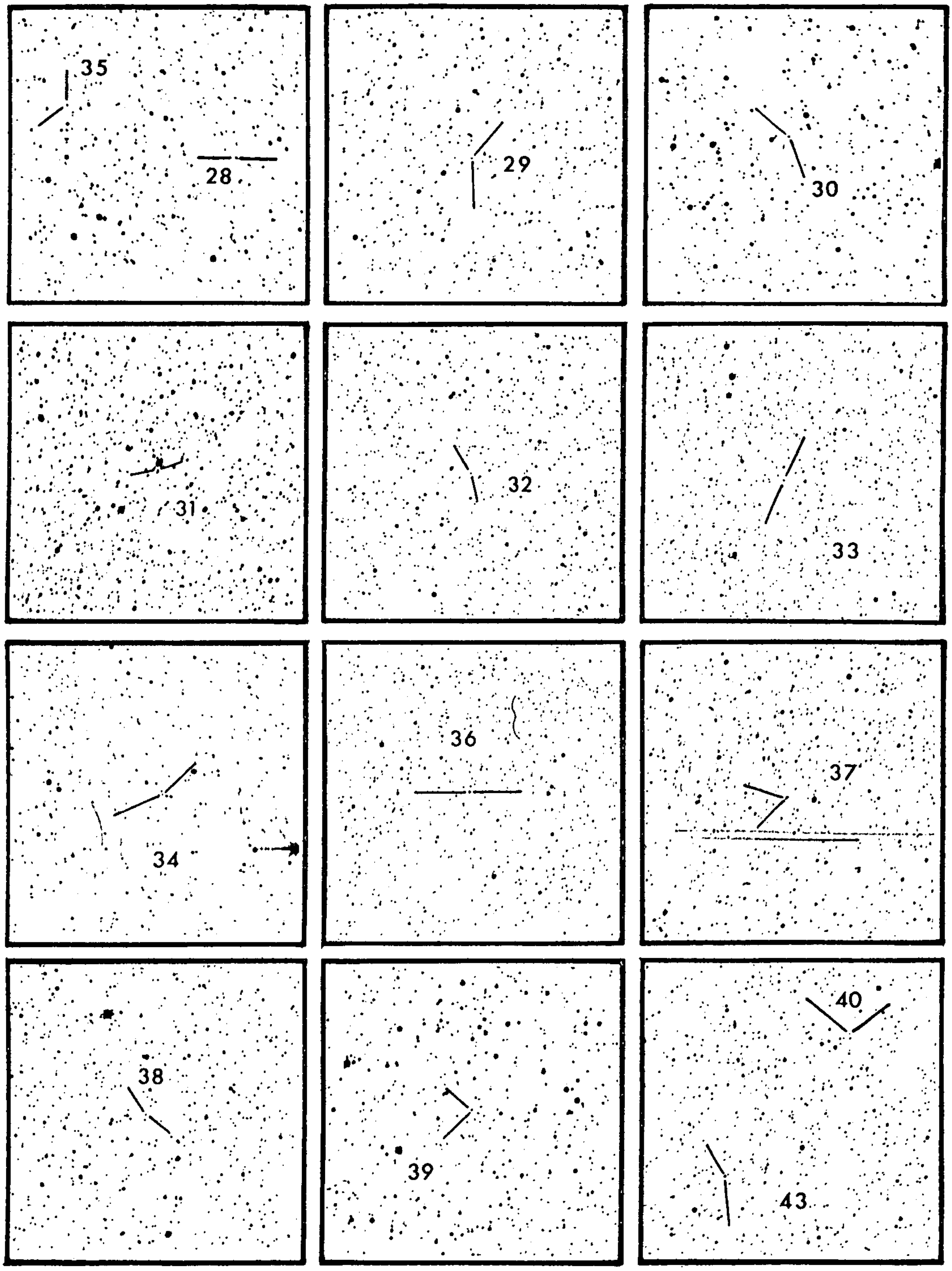
Orientation : North is at the top, east to the left.

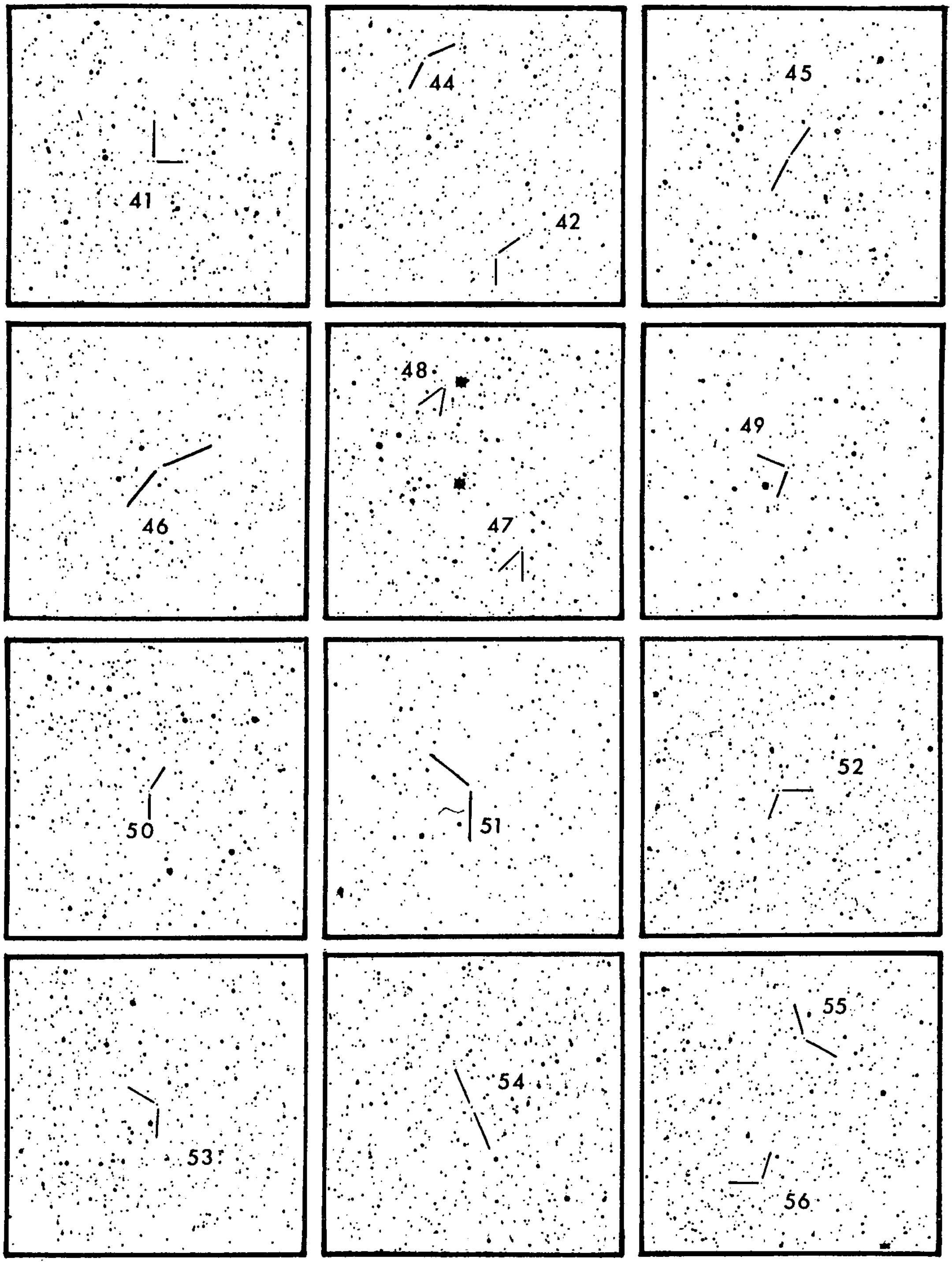
Note: No. 186 is the right one of two close stars.

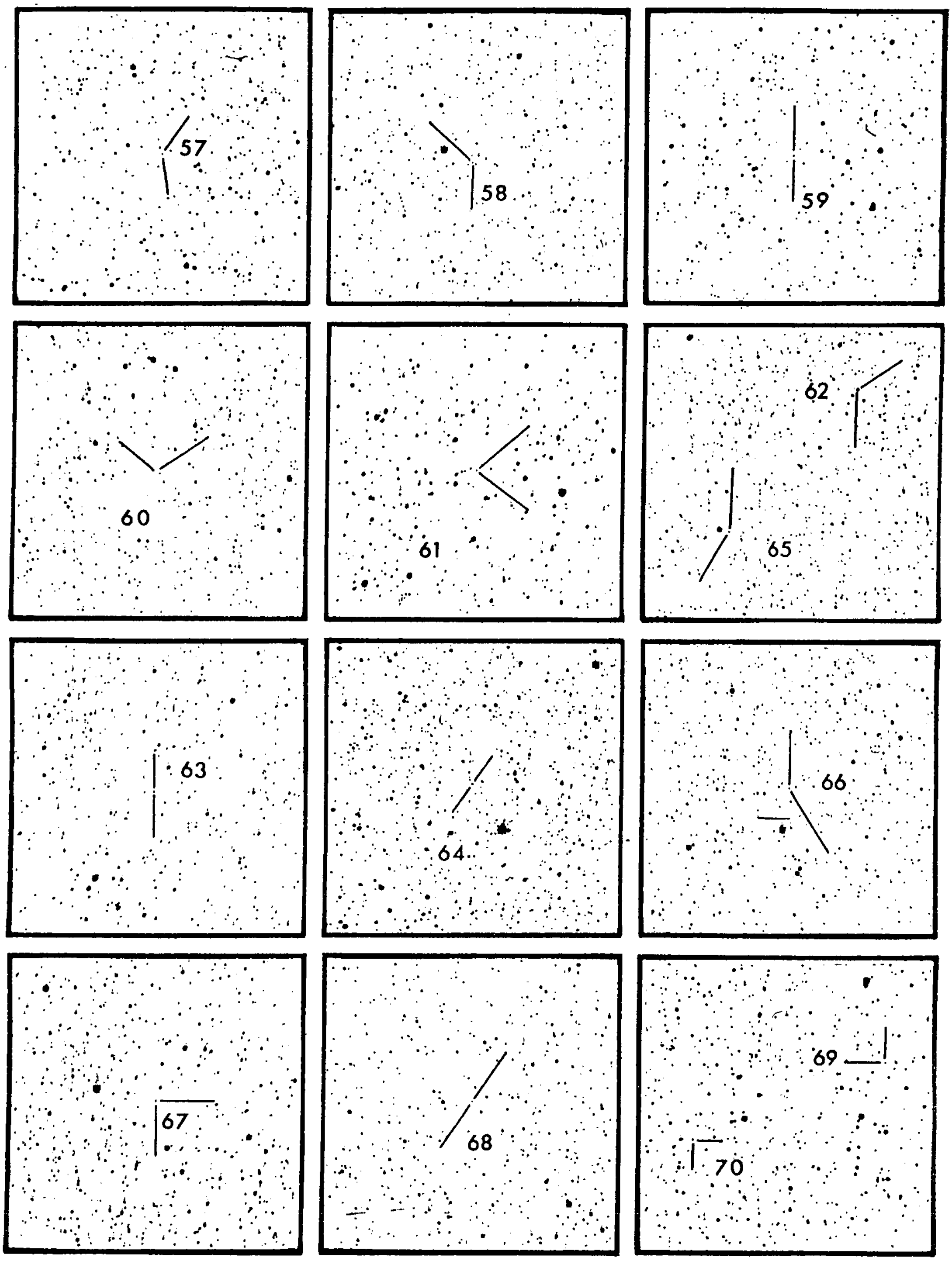
No. 188 is the left one of two close stars.

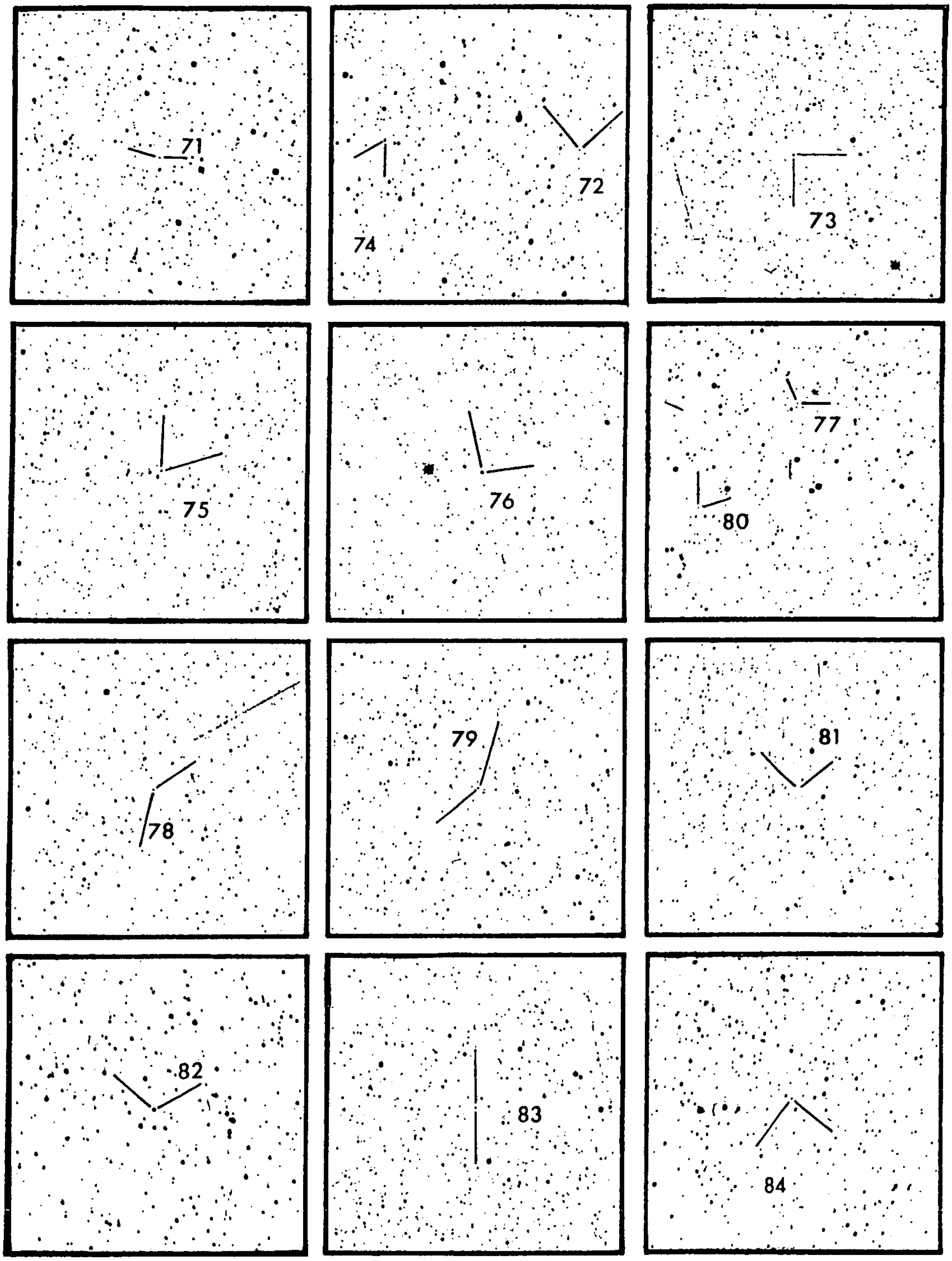

1
2
3
4
5
6
7
8
12
11
9
10
13
14

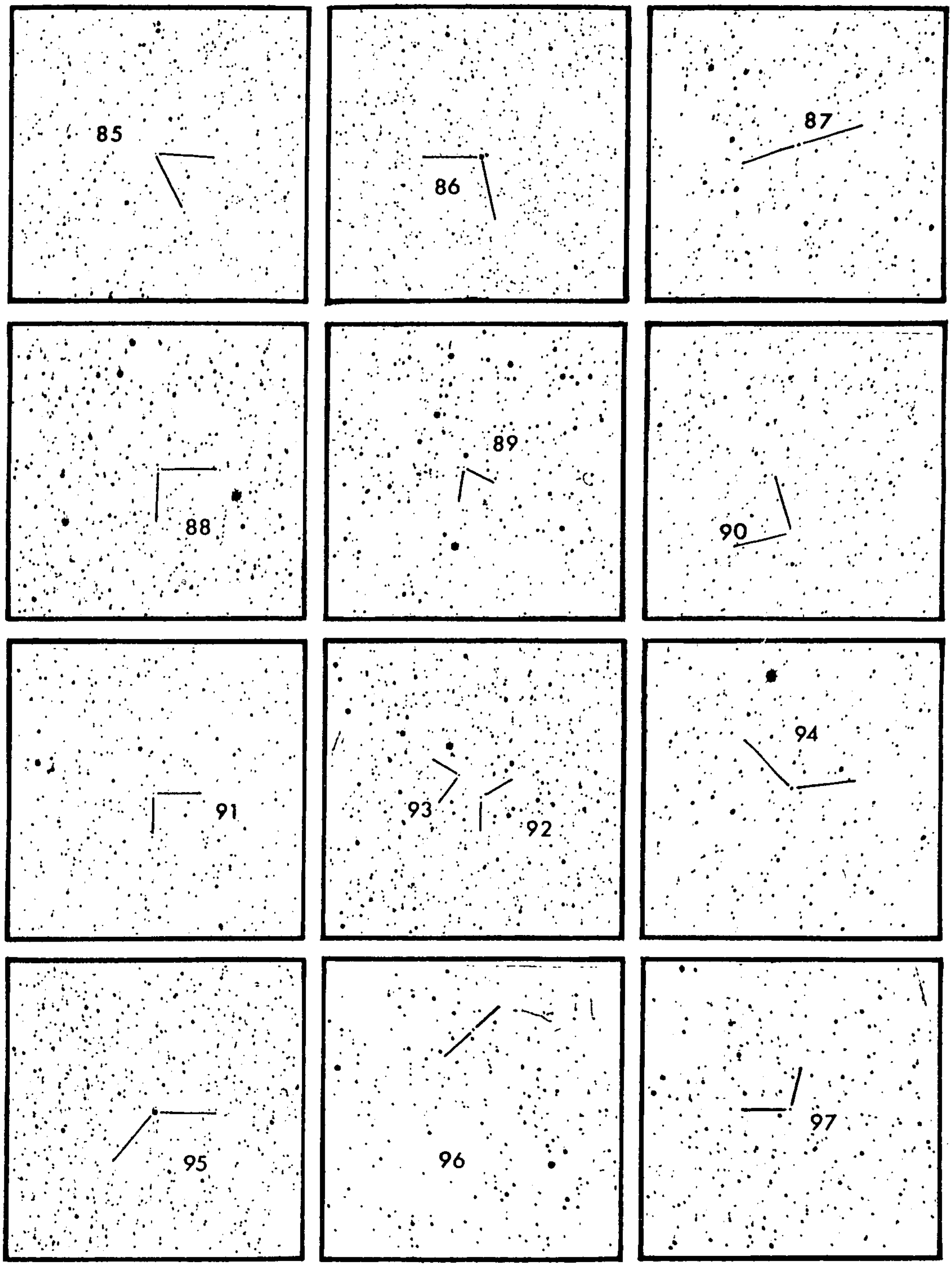

15
16
17
18
19
20
21
22
23
24
25
26
27

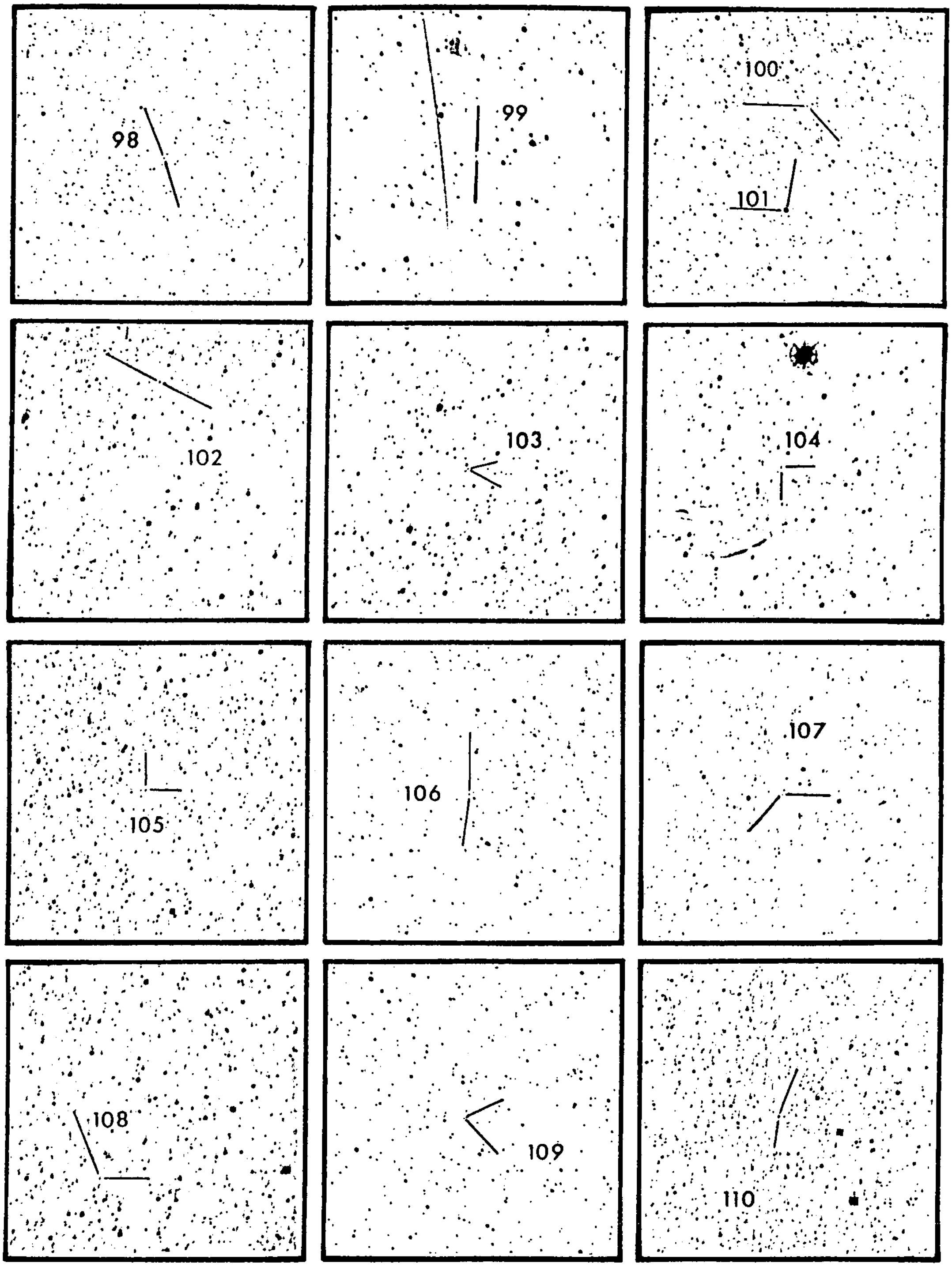

35
28
29
30
31
32
33
34
36
37
38
39
40
43

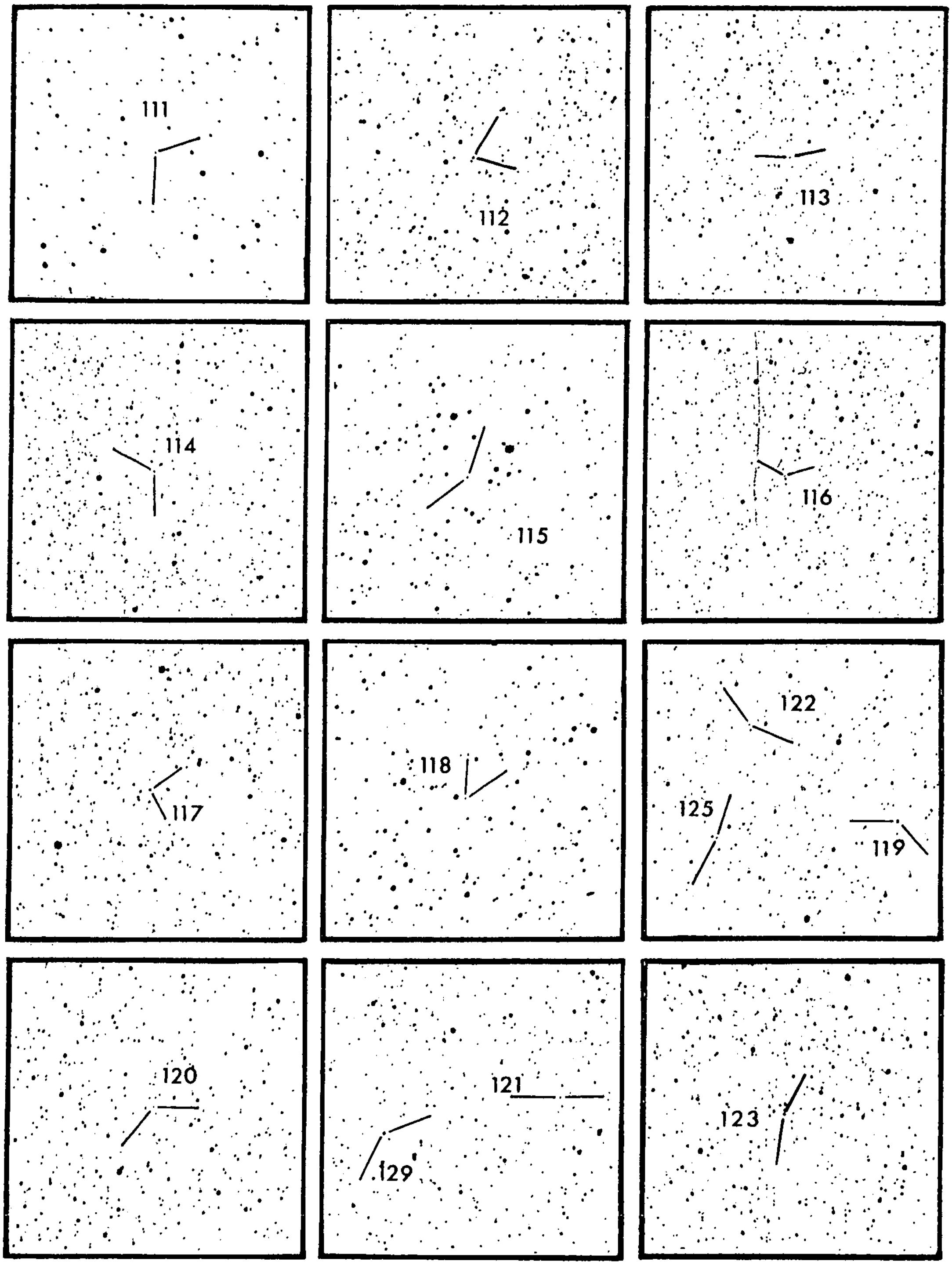

44
42
45
41
48
47
49
46
52
50
51
55
54
53
56

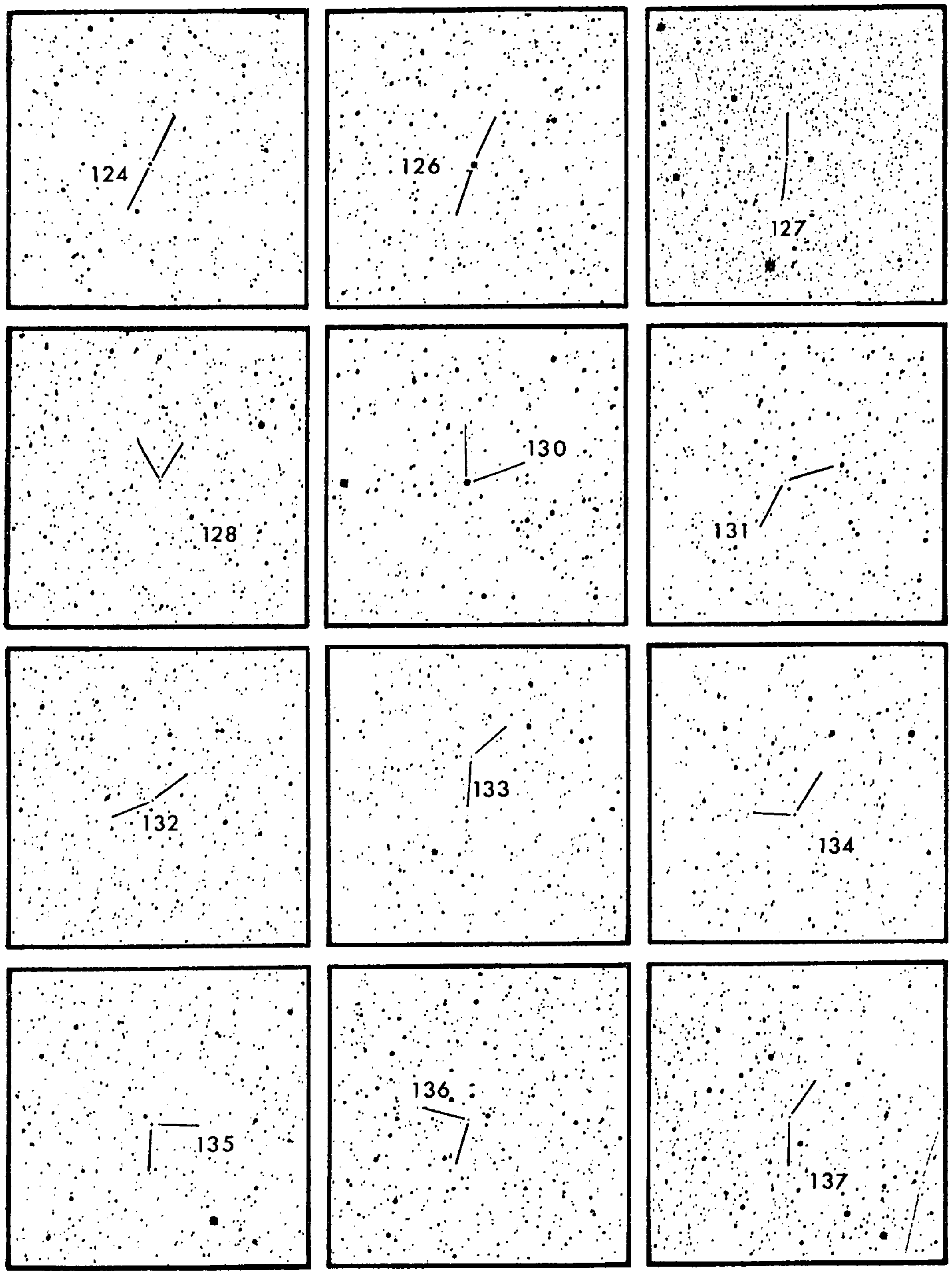

57
58
59
60
61
62
65
63
64
66
67
68
69
70

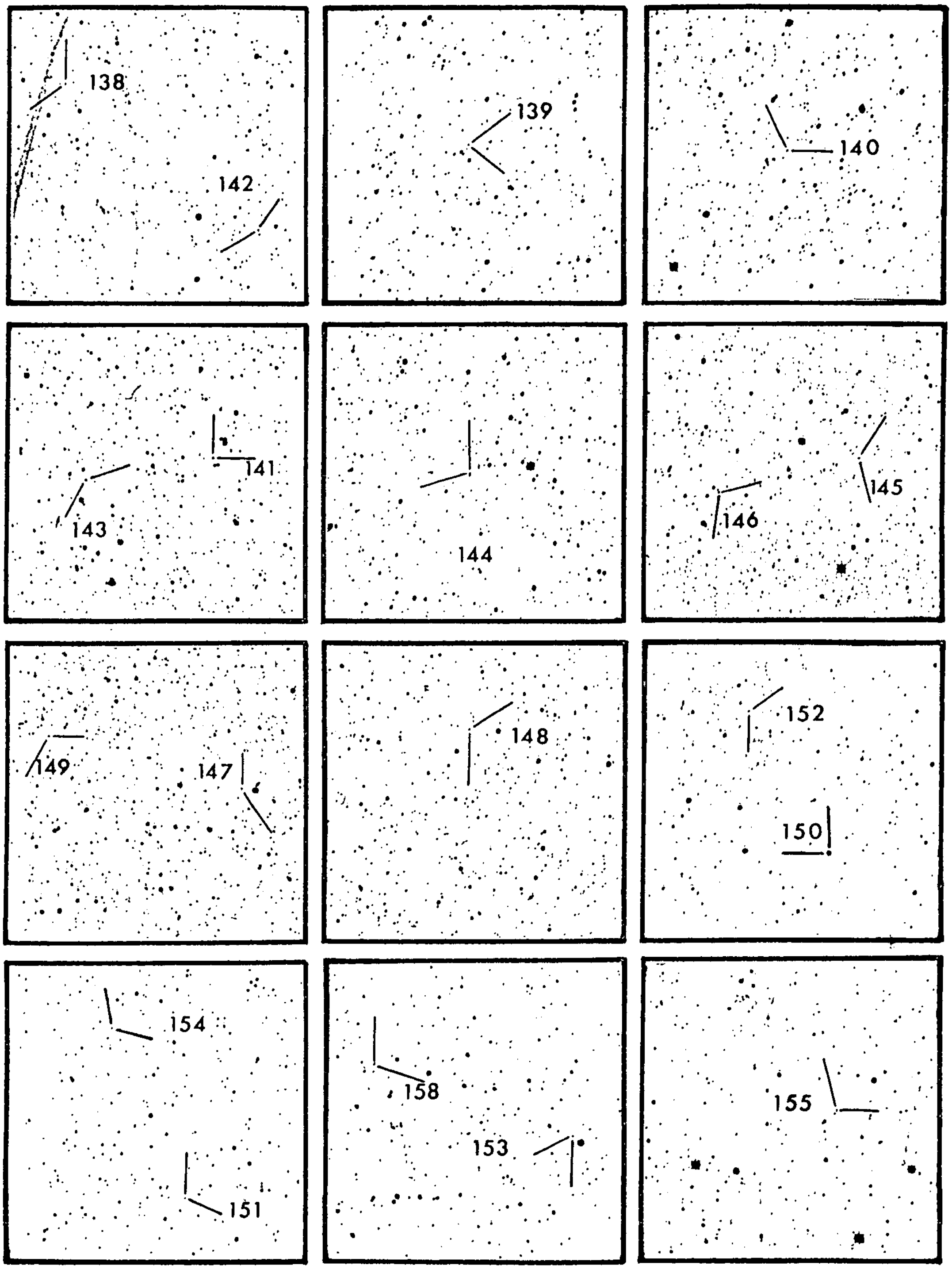

71
72
74
73
75
76
77
80
78
79
81
82
83
84

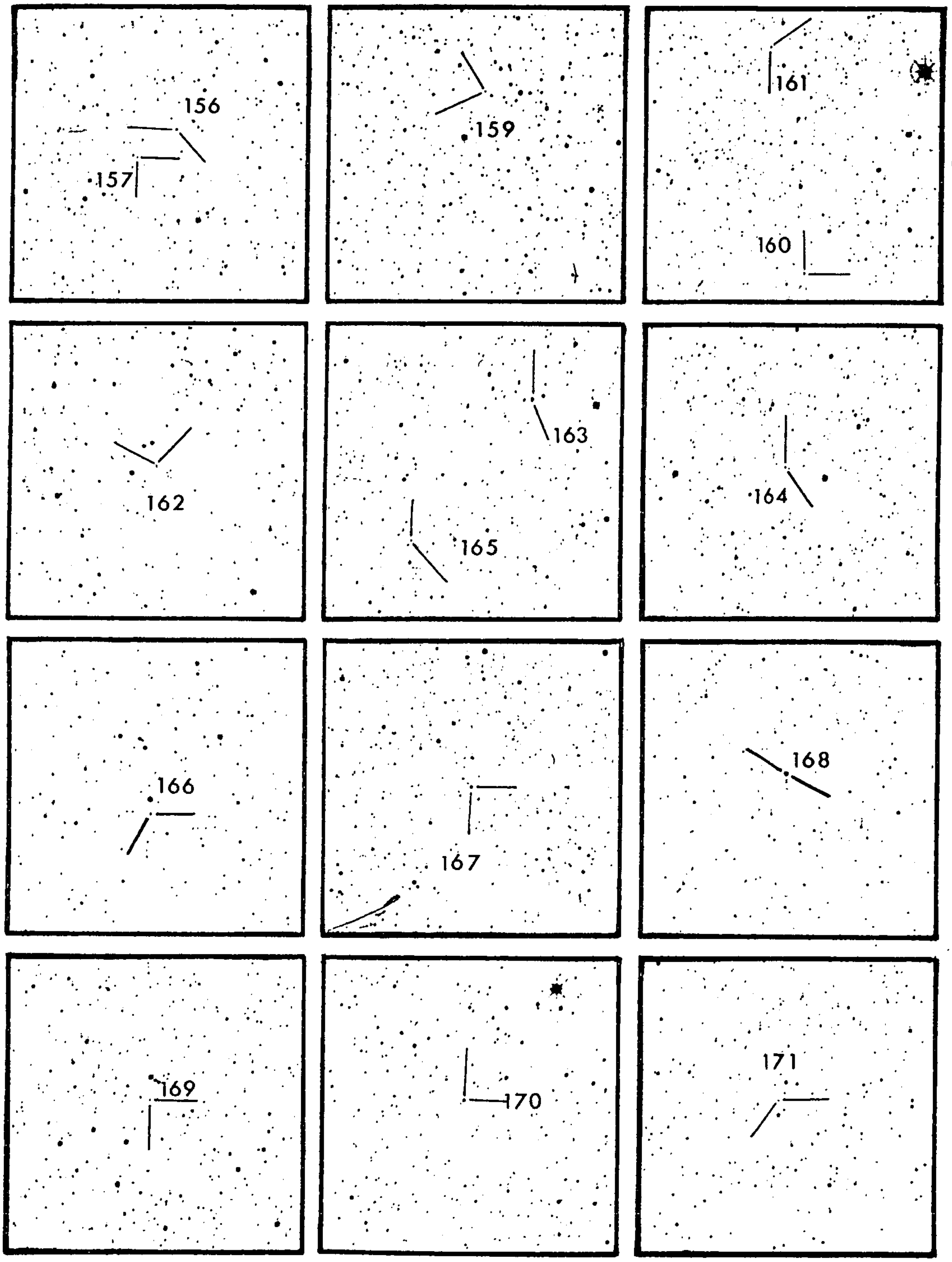

85
86
87
88
89
90
91
93
92
94
95
96
97

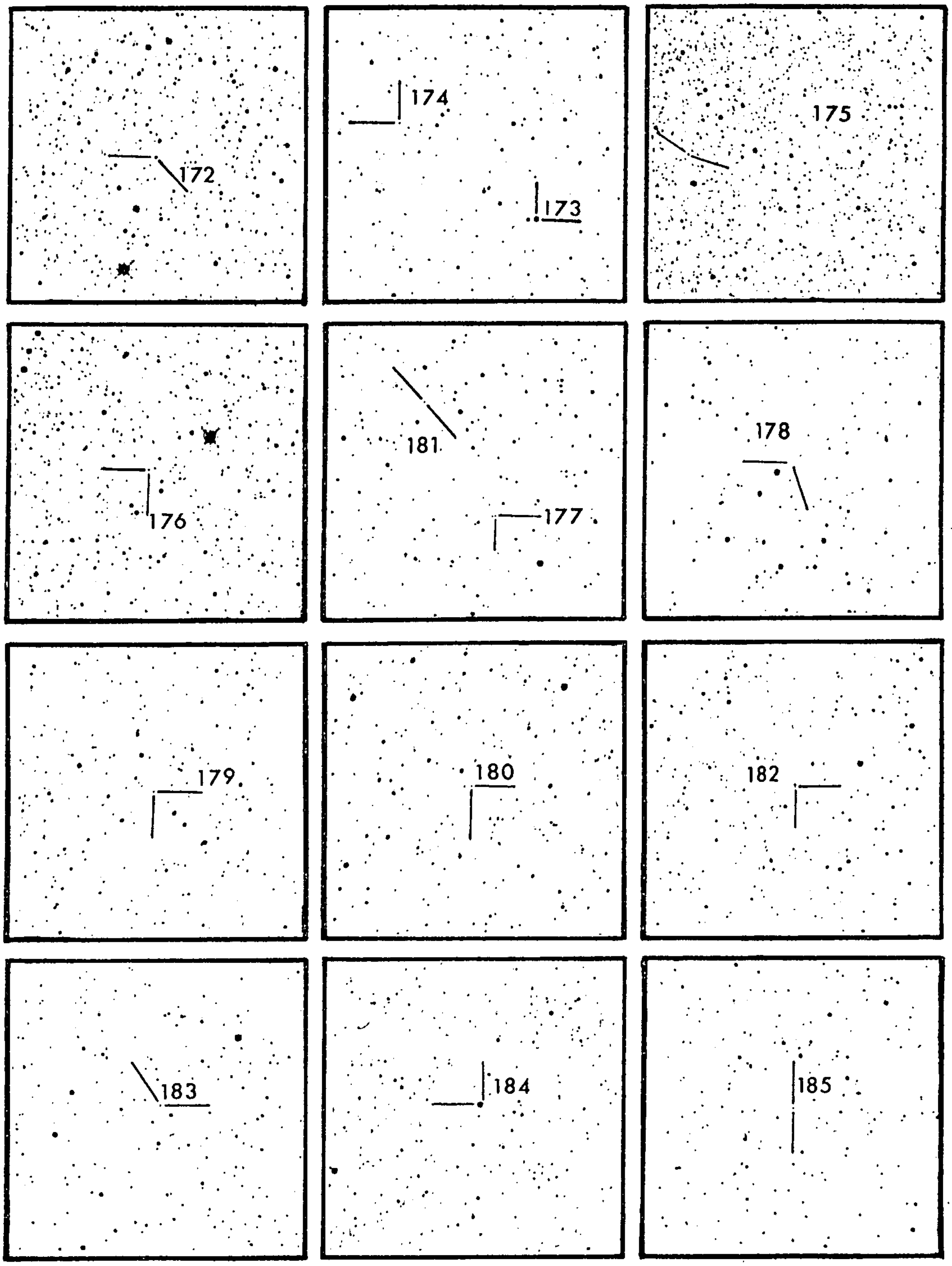

98
99
100
101
102
103
104
105
106
107
108
109
110

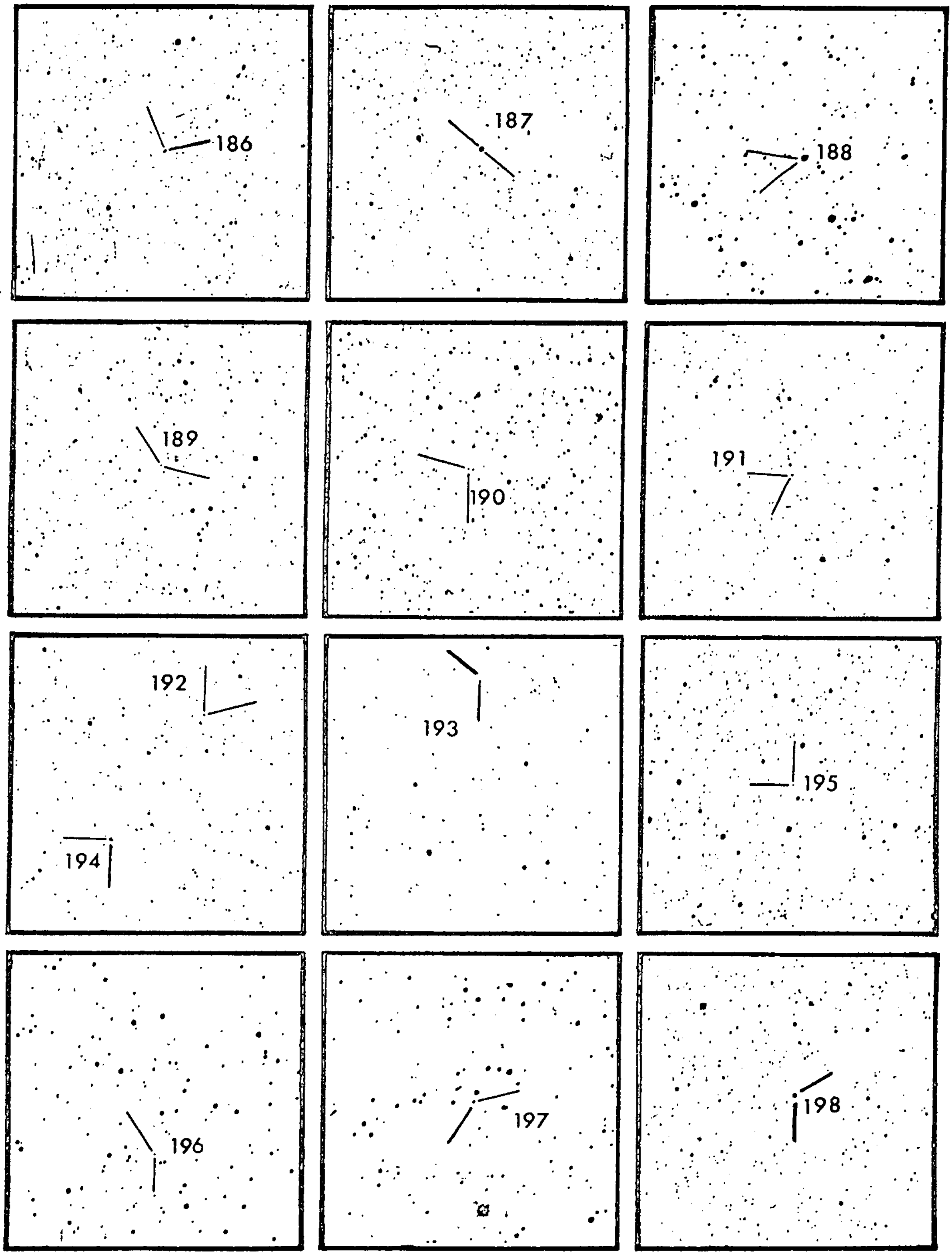

111
112
113
114
115
116
117
118
122
125
119
120
121
129
123

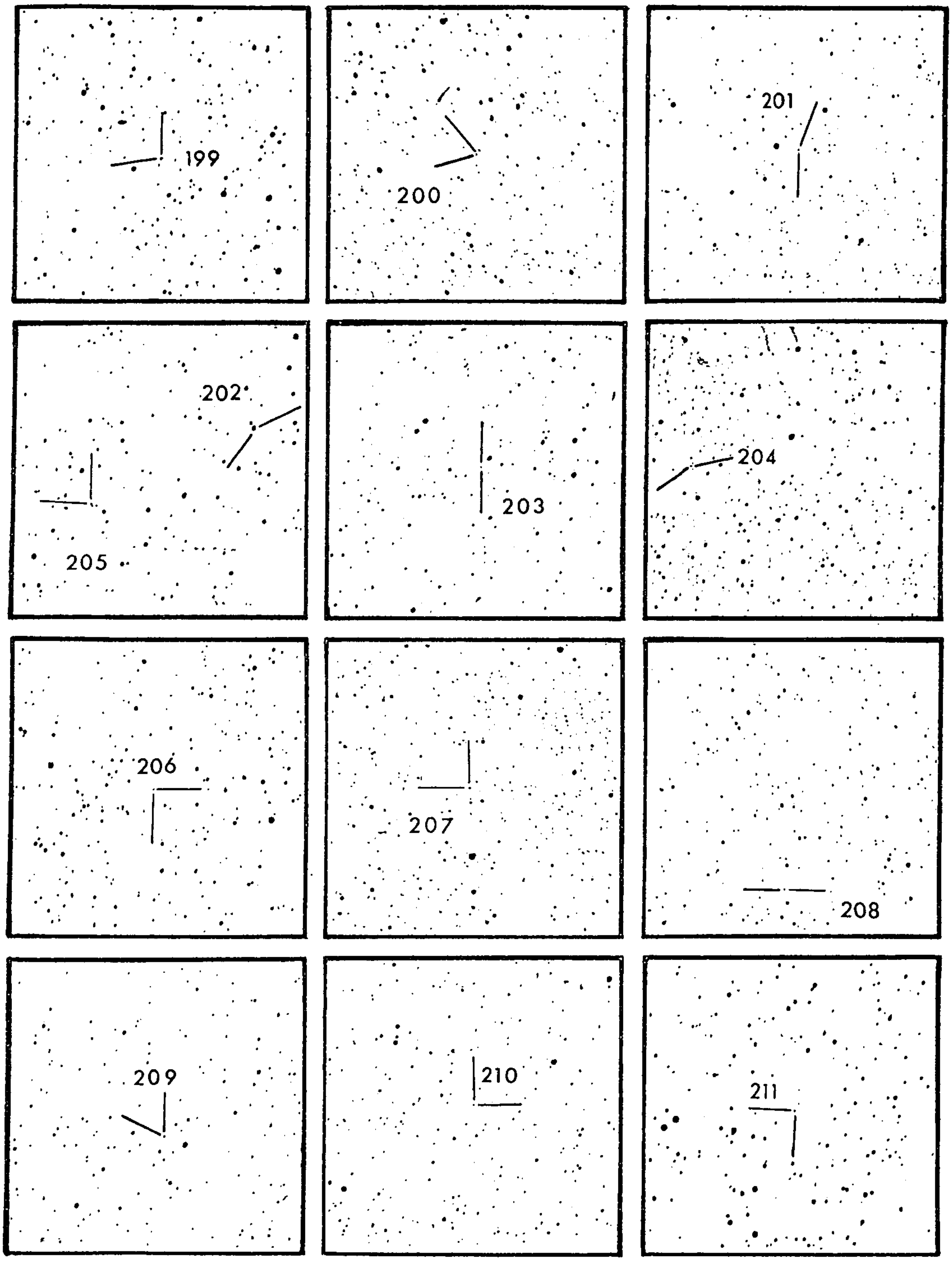

124
126
127
128
130
131
132
133
134
135
136
137

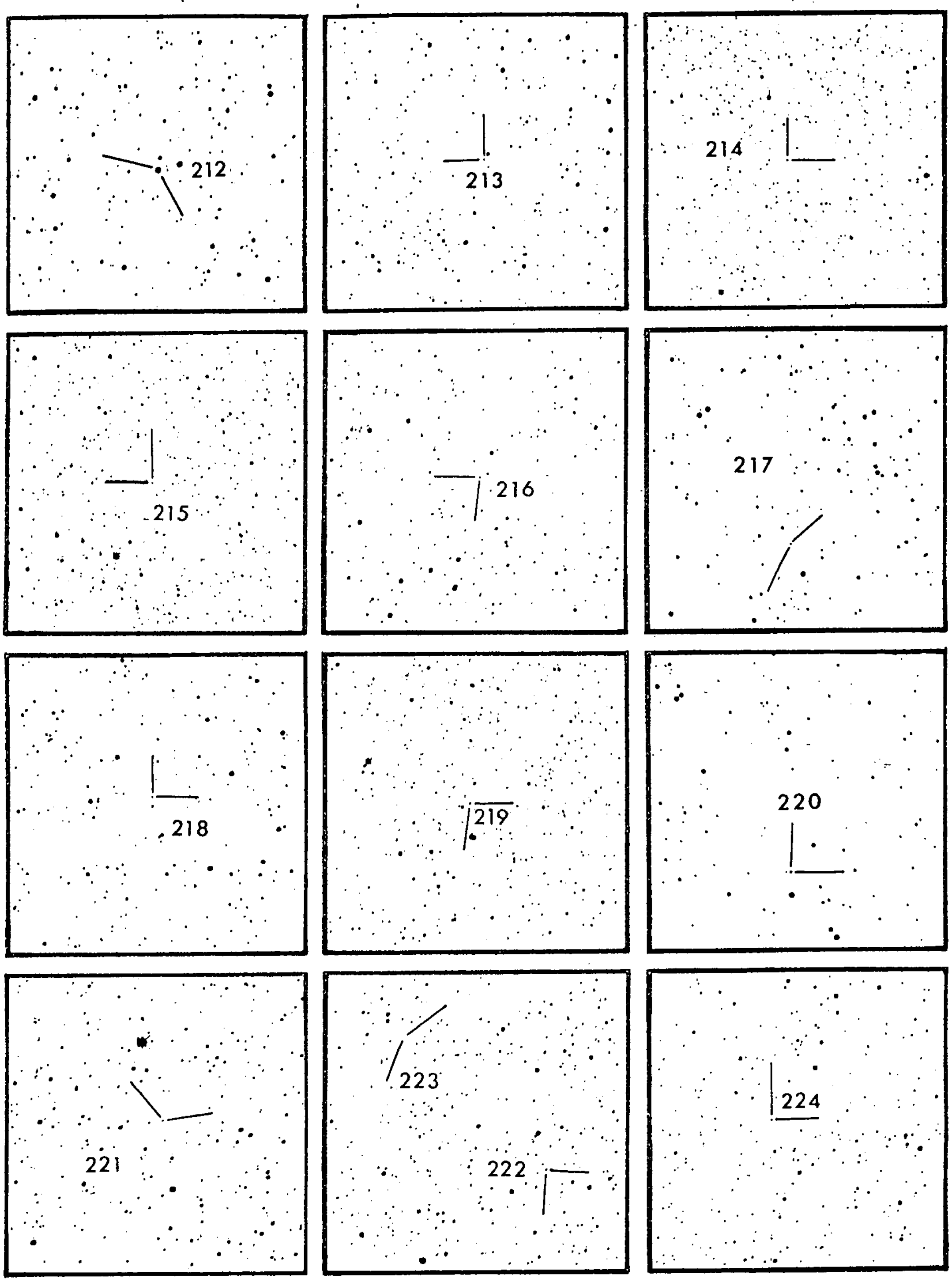

138
142
139
140
141
143
144
146
145
149
147
148
152
150
154
151
158
153
155

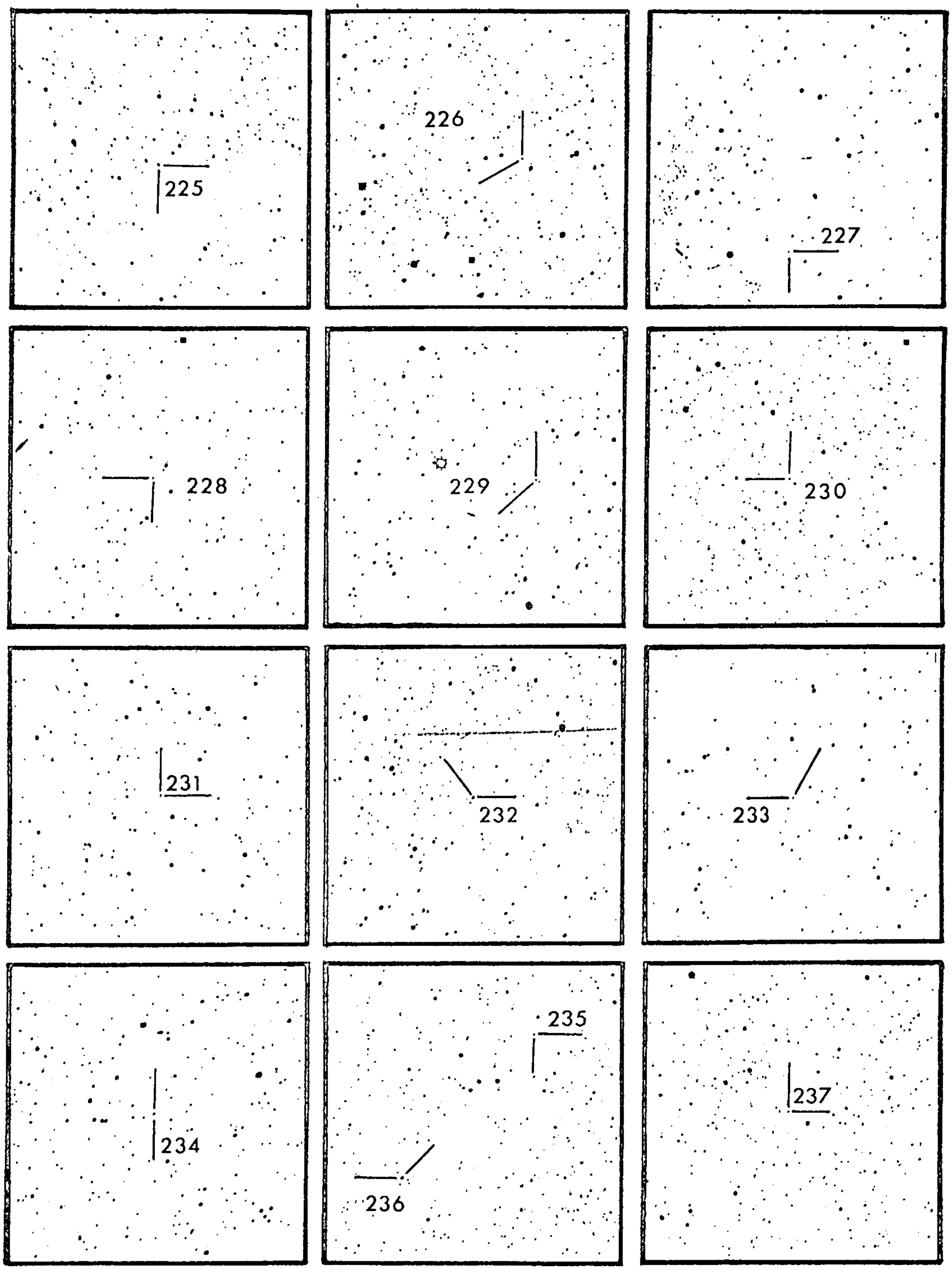

156
157
159
161
160
162
163
165
164
166
167
168
169
170
171

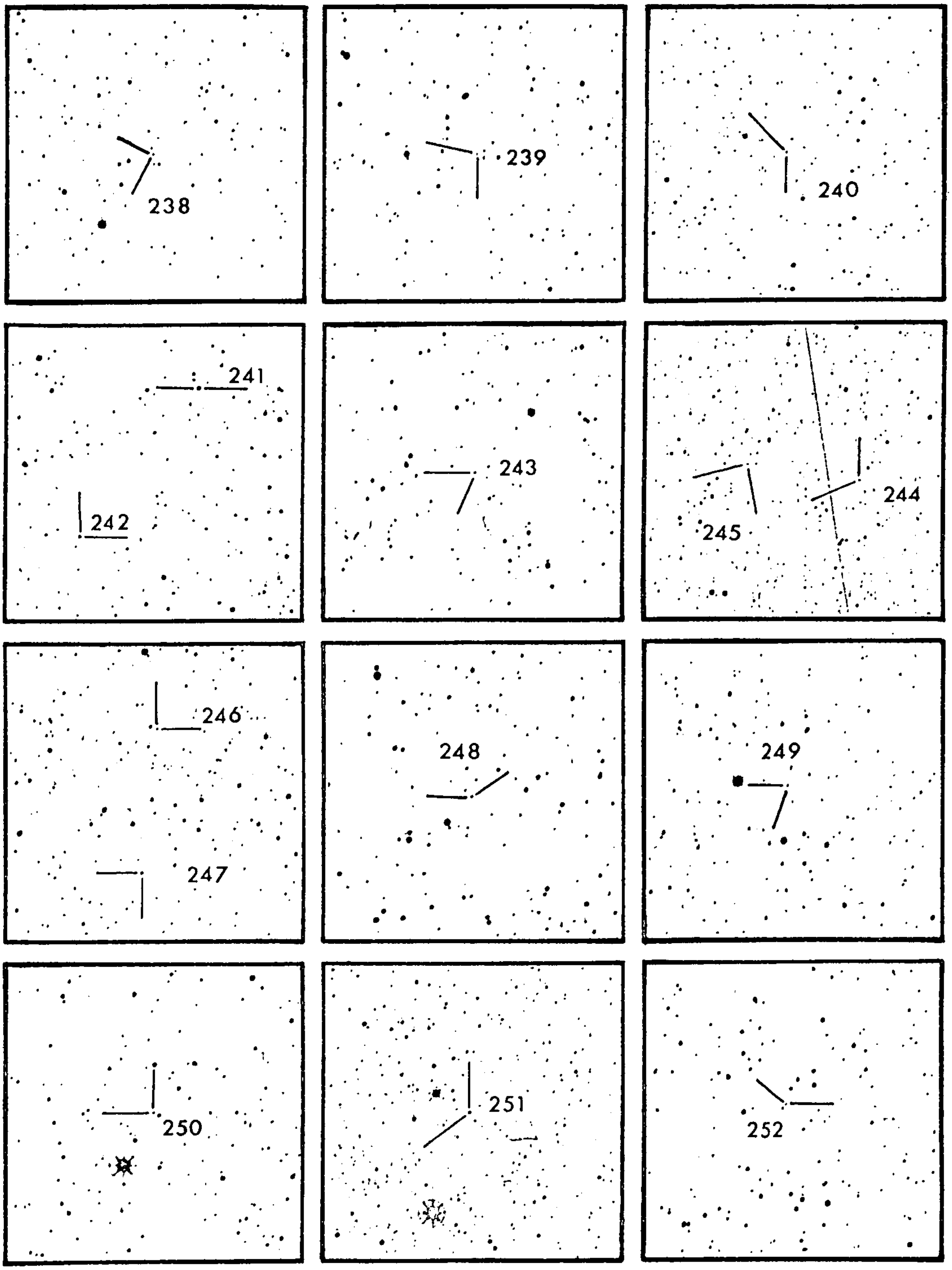

172
174
173
175
176
181
177
178
179
180
182
183
184
185

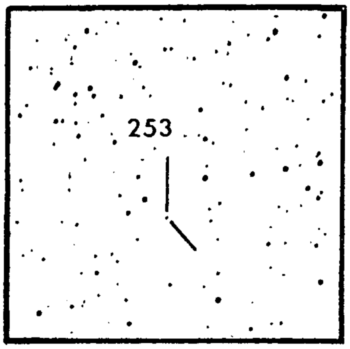

186
187
188
189
190
191
192
193
194
195
196
197
198


199
200
201
202
205
203
204
206
207
208
209
210
211

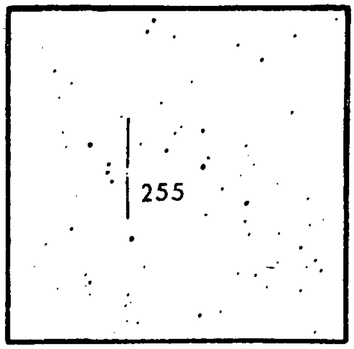

212
213
214
215
216
217
218
219
220
221
223
222
224

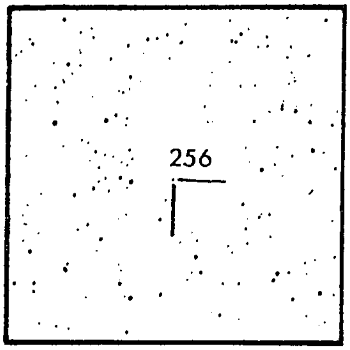

225
226
227
228
229
230
231
232
233
234
235
236
237

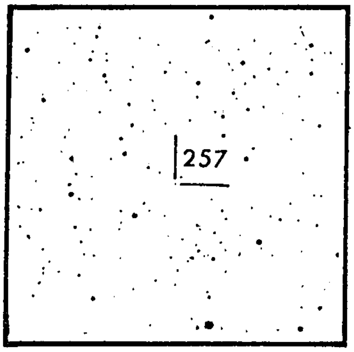

238
239
240
241
242
243
244
245
246
247
248
249
250
251
252

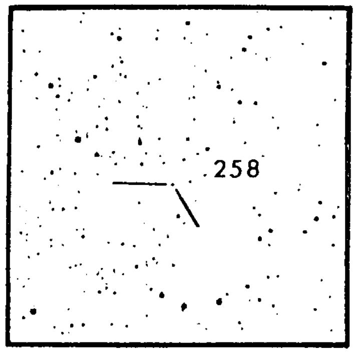

253

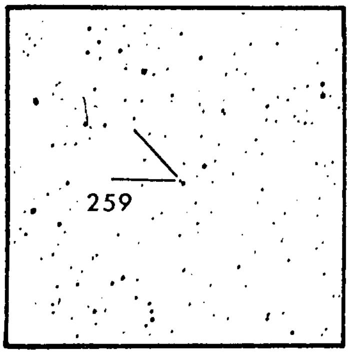

254

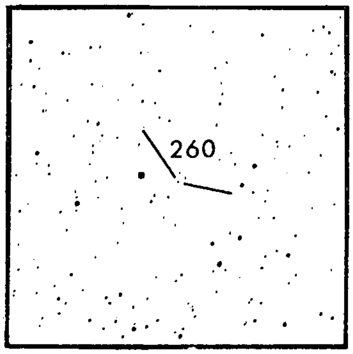

255

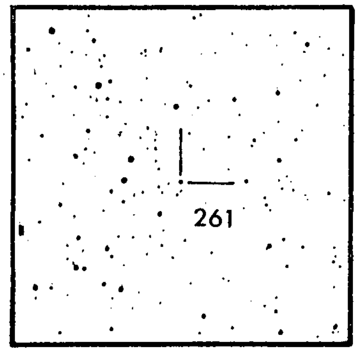

256

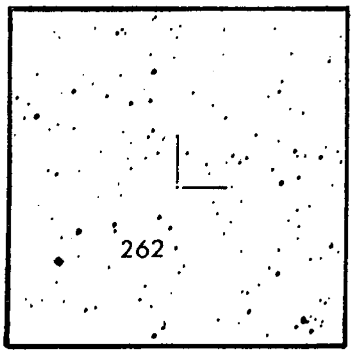

257

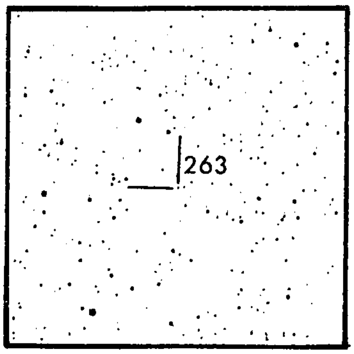

258

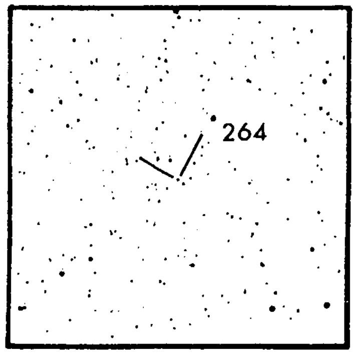

259

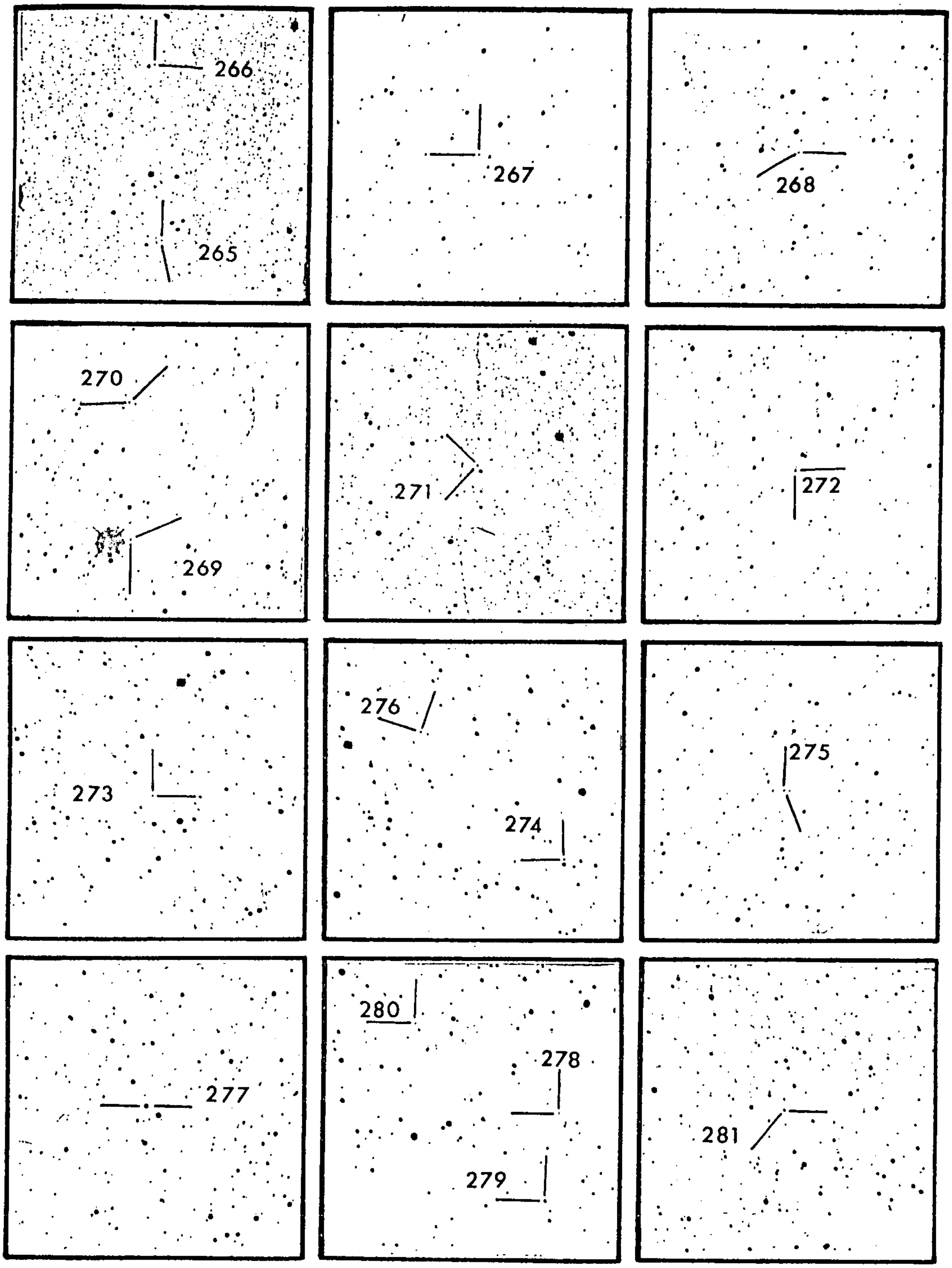

260

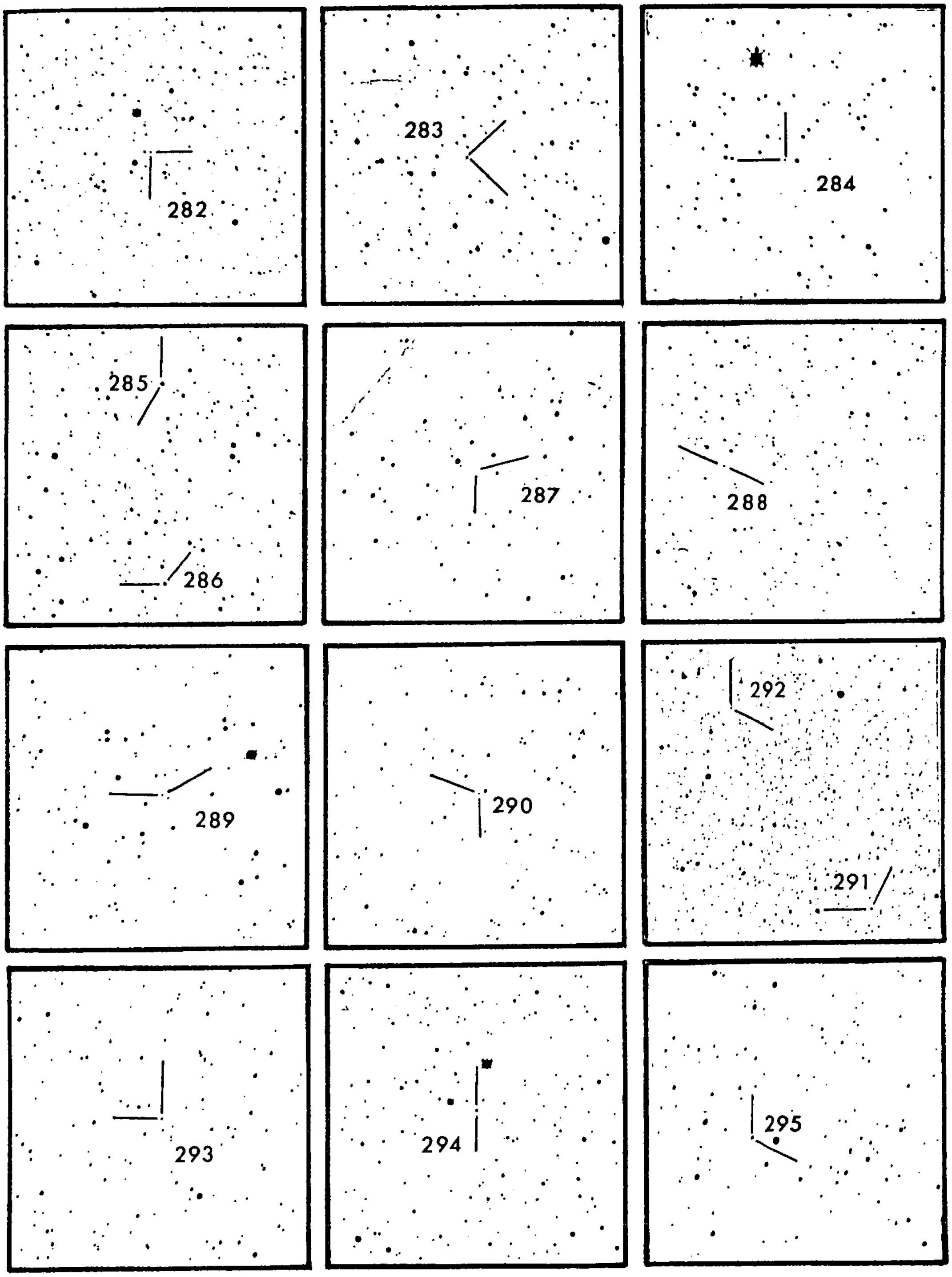

261

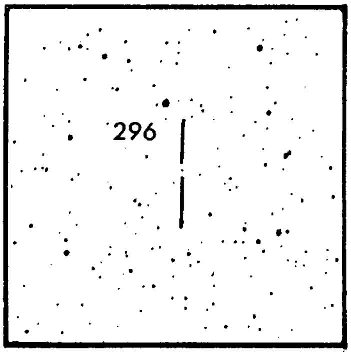

262


263


264


266
265
267
268
270
269
271
272
273
276
274
275
277
280
278
279
281


282
283
284
285
286
287
288
289
290
292
291
293
294
295


296

2.2.8 Comparison between present survey and those by Luyten

To make a comparison between the present survey and those by Luyten, the U, B plates were inspected at coordinates published in series XII and XVIII of A Search for Faint Blue Stars (in the far southern hemisphere) by Luyten and Anderson (1958, 1959). Some coordinates of L white dwarfs were from Magnitudes and Colours for Southern White Dwarfs by Luyten and Smith (1958). It was found that 5 LB stars and 5 L white dwarfs are in the intermediate latitude area and 87 LB stars and 12 L white dwarfs are in the high latitude area. The coordinates of these stars were plotted on the plate scale.

In the first area one LB star was identified with a possible violet star, 2 L white dwarfs with definitely violet stars and one with a probably violet star. In the second area 11 LB stars were identified with definitely violet stars and 3 with possibly violet stars, one L white dwarf with definitely and 3 L white dwarfs with possibly violet stars.

In conclusion, only 16% of the LB stars and

41% of the L white dwarfs in both area were identified with violet stars on the U, B plates. The major reason for the small proportion of identifications is that the present study aims at including only stars more violet than those with $U - B = - 0^m.6$.

2.2.9 Comparison between present survey and radio sources

To attempt an identification of radio sources on the present plate material, the U, B plates were inspected at coordinates of radio sources obtained from the Parkes Catalogue by Shimmins, Clarke and Ekers (1966). Altogether, 4 radio sources are situated inside the intermediate latitude area and another 4 in the high latitude area. Four other radio sources (PKS 1754-59, 1814-63, 0013-63 and 0210-62) which are not in the search areas were also included. The coordinates of these radio sources were plotted on the plate scale.

It was found that none of the radio sources could be identified with a violet object on the U, B plates.

2.3 Photoelectric Observations

Of the violet stars found, 43 were observed photoelectrically in UBV colours. Out of these, 25 were measured also in a red colour (R') in order to distinguish between quasi-stellar galaxies and white dwarfs.

2.3.1 Photoelectric photometers

In order to measure UBV colours of the 43 violet stars, single-channel photoelectric photometers were used with the 40-inch and the 24-inch reflecting telescopes at Siding Spring Observatory, and a two-channel photoelectric photometer with the 50-inch reflector at Mt. Stromlo Observatory. Cells used are of type RCA 1P21 and the equipment is similar to that described by Johnson (1962).

To measure the stars in R', a red cell (RCA 7102) was used with the 40-inch reflector at the Siding Spring Observatory. Because the programme stars are very faint, a GG 14 filter was used to record as much of the yellow, red and infra-red radiation as possible.

2.3.2 Reduction procedure for UBV observations

Data obtained from photoelectric observations were reduced in two steps: first a correction was made for atmospheric extinction; second the instrumental system was transformed to a common system of magnitude and colour (UBV system).

Atmospheric Extinction

It was assumed that the extinction coefficients determined for standard stars, which were observed a few times each night, can be used for the programme stars observed in the same night.

Let C be the apparent magnitude of a star at the earth's surface and C_o the apparent magnitude of the star immediately above the earth's atmosphere. e is the extinction coefficient, and Z is the zenith distance of the star at the time it is observed. The value of sec Z was used for the value of air-mass (m) because Z of each observed star was less than 65^{o}.

The formulae used are

$$v - v_o = e_V \sec Z$$

$$(b - v) - (b - v)_o = \left[e_{\{(b - v)_o = 0\}} - 0.04(b - v) \right] \sec Z$$

$$(u - b) - (u - b)_o = e_{(u - b)} \sec Z.$$

The range in value of extinction coefficients used is shown in Table 2.4 below.

Table 2.4

Extinction coefficients	Magnitude per unit of air-mass
e_V	0.140-0.165
$e_{\{(b - v)_o = 0\}}$	0.125-0.150
$e_{(u - b)}$	0.330-0.360

Transformation

After correction for atmospheric extinction we obtained v_o, $(b - v)_o$ and $(u - b)_o$ values for every observed star. By plotting $(V - v_o)$ against $(B - V)$, $(B - V)$ against $(b - v)_o$ and $(U - B)$ against $(u - b)_o$ of standard stars we obtained for the 40" run, 8-11/8/1967:

$$V = v_o + x,$$
$$B - V = 1.151 + 0.973(b - v)_o,$$
$$U - B = -1.110 + 0.977(u - b)_o,$$

where x varied from 11.400 to 11.490 between different nights. For other observing runs similar relations were obtained.

2.3.3 Red colour (R') observations

In the red colour (R') observations, six standard stars, 47 Tuc α, a and g, and NGC 6397 a, b and 211 (notation according to Brooke, 1968), were observed in the same nights as the programme stars. The standard stars are of types ranging from about A7 to K4. A mean extinction coefficient of 0.08 magnitude per unit of air-mass was used throughout. From the six standard stars it was found that the resulting colour (R') closely resembled that of the R colour of Johnson's revised system (Johnson, 1966). The relation found was V - R' = 1.01 (V - R). The wide R' band may well differ from the R band for other stellar types. However, as the effects expected should be large, the R' colour should be accurate enough to separate quasi-stellar objects from white dwarfs.

2.3.4 Influence of interstellar reddening

Interstellar absorption is higher for short than for long wavelengths. A star subjected to a visual absorption A_V has a colour excess $E_{B - V}$. Blanco (1956) had discussed the ratio of the total to selective absorption on the B - V system, and found that :-

$$R = \frac{A_V}{E_{B - V}} = 3.$$

Johnson and Morgan (1953), and Hiltner and Johnson (1956) investigated the possibility of variations in the ratio of the colour excesses $\left[\frac{E_{U - B}}{E_{B - V}}\right]$, for O type stars and obtained the formula:-

$$\frac{E_{U - B}}{E_{B - V}} = 0.72 + 0.05E_{B - V}.$$

The colour excesses for stars outside the main galactic absorption layer were calculated for the two search areas by assuming:

$$A_V = 0.19 \text{ cosec } b^{II},$$

$$E_{B-V} = \frac{1}{3}A_V,$$

and $$E_{U-B} = \frac{2}{9}A_V.$$

The results obtained are shown in Table 2.5.

Table 2.5

Observed areas	Expected colour excesses for extra-galactic objects and distant halo stars	
	E_{B-V}	E_{U-B}
Intermediate latitude area	$0^m.107$	$0^m.071$
High latitude area	0.070	0.047

2.3.5 Photoelectric results for the measured violet stars

Photoelectric results for 43 violet stars are given in Table 2.6. From these results the mean values were deduced of estimated properties. These are given in the introduction to the table of section 2.2.6.

In Table 2.6 the last column (n) represents the number of observations. The first figure gives the number of observations in UBV colours and the last figure the number of R' observations. Data in brackets were obtained on a night when smoke from a bush-fire in the neighbourhood made observations less reliable.

Table 2.6

Cat. No.	V	B - V	U - B	V - R'	n
1	14.73	- 0.18	- 0.97	+ 0.14	2, 1
2	16.71	- 0.16	- 0.65	-	2
6	13.80	- 0.19	- 0.73	- 0.18	2, 1
9	13.23	- 0.28	- 1.20	- 0.40	2, 1
11	16.73	0.00	- 1.17	-	1

Cat. No.	V	B - V	U - B	V - R'	n
13	16.01	- 0.32	- 1.23	- 0.22	2, 1
15	16.94	- 0.22	- 0.98	-	1
23	16.25	- 0.32	- 1.20	-	1
25	13.28	- 0.19	- 1.09	- 0.23	2, 1
26	15.35	- 0.25	- 1.08	- 0.17	3, 1
29	16.42	- 0.07	- 1.06	-	2
33	15.07	- 0.05	- 0.89	- 0.02	2, 1
36	12.93	- 0.16	- 0.86	- 0.30	2, 1
37	14.18	- 0.12	- 0.67	+ 0.33	2, 1
42	16.54	+ 0.14	- 1.26	-	1
43	13.96	+ 0.64	- 0.27	+ 0.30	2, 1
48	17.3	+ 0.6	- 0.8	+ 0.9	1, 1
53	15.88	- 0.27	- 1.14	+ 0.15	2, 1
96	14.46	+ 0.04	- 0.92	- 0.22	2, 1
99	15.06	- 0.13	- 1.06	- 0.01	2, 1
111	14.00	- 0.12	- 1.02	- 0.09	2, 1
117	14.39	- 0.36	- 1.23	- 0.41	2, 1
119	13.48	- 0.27	- 1.14	- 0.19	1, 1
122	17.5	- 0.1	- 0.8	-	1

Cat. No.	V	B - V	U - B	V - R'	n
125	17.2	- 0.0	- 1.3	-	2
133	17.2	- 0.1	- 1.2	-	2
134	15.32	- 0.03	- 0.97	- 0.15	2, 1
150	10.15	+ 0.50	- 0.03	(0.00)	2, 1
162	16.37	+ 0.42	- 1.11	-	1
163	12.88	- 0.17	- 0.94	(- 1.04)	1, 1
166	15.23	- 0.23	- 1.11	(- 0.27)	2, 1
171	17.4	- 0.6	- 1.2	-	2
225	(14.34)	(+ 0.59)	(- 0.06)	(+ 0.22)	1, 1
234	(15.68)	(+ 0.15)	(- 1.26)	(- 1.07)	1, 1
236	(13.45)	(- 0.28)	(- 1.04)	(- 0.23)	1, 1
249	(16.01)	(- 0.25)	(- 1.30)	-	1
256	15.60	- 0.35	- 1.04	-	3
278	17.1	+ 0.4	- 0.4	-	1
279	14.68	- 0.24	- 0.84	-	2
285	12.77	- 0.32	- 0.98	-	2
286	14.31	- 0.22	- 0.82	-	2
288	(17.7)	(+ 0.5)	(- 0.8)	(+ 1.2)	1, 1
295	14.53	- 0.26	- 1.04	-	1

CHAPTER III

COLOURS OF OBJECTS

3.1 Two-colour Diagram of Objects

To study the distribution of objects in a two-colour plane, colours (U - B, B - V) of objects were plotted (Figure 3.1). The main-sequence is from Johnson (1966) and the black-body line from Matthews and Sandage (1963). The data for 37 hot subdwarfs (SD(O - B)), 172 white dwarfs (WD), 76 quasi-stellar sources (QSS), 6 quasi-stellar galaxies (QSG), 128 subdwarfs (SD(F - G)) and 26 blue horizontal-branch stars (HB) are from Greenstein (1960, 1966), Slettebak, Bahner and Stock (1961), Sandage and Walker (1964), Sandage (1964, 1965), Eggen and Greenstein (1965),

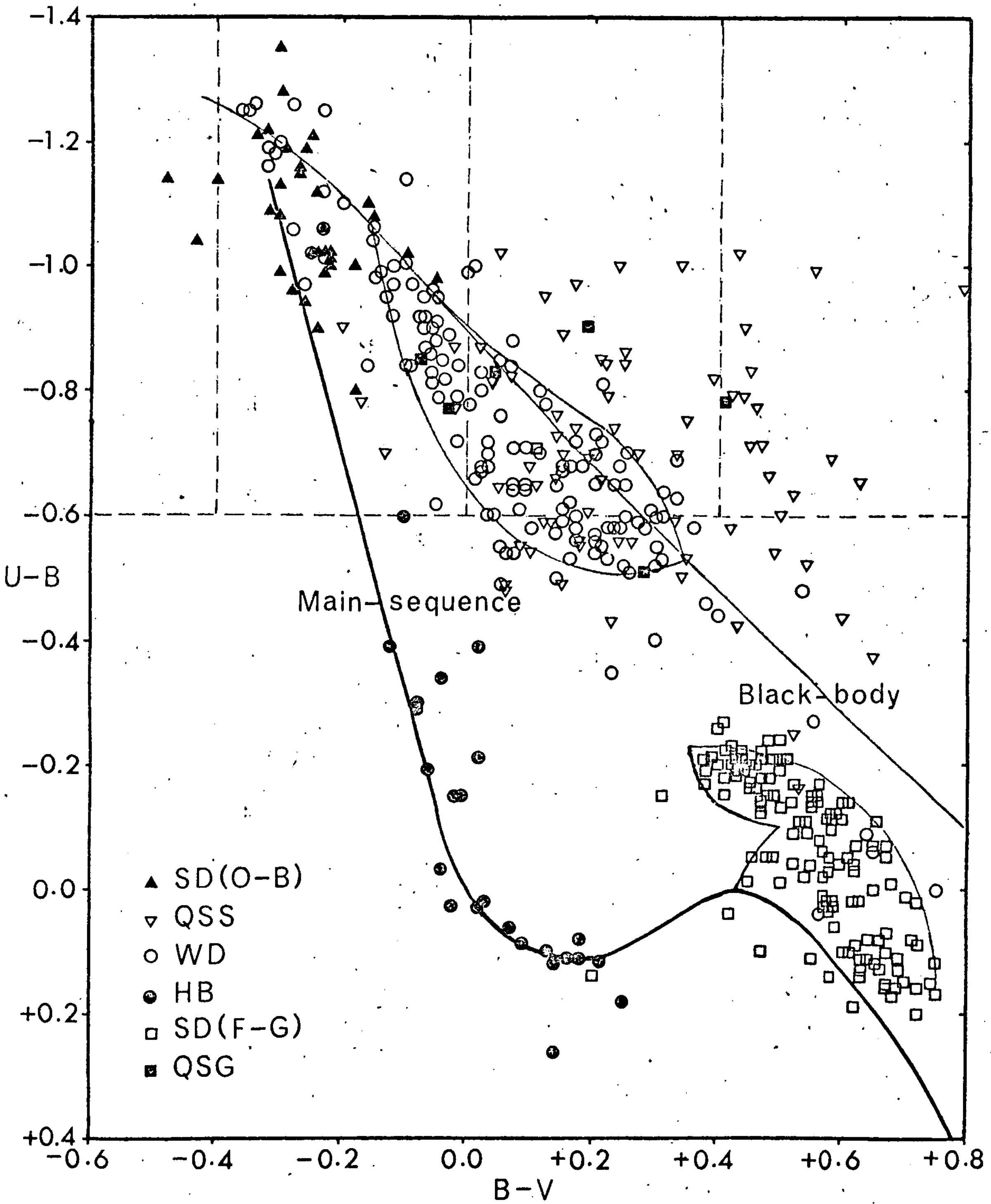


Figure 3.1 A [U-B, B-V] diagram of main-sequence stars, black-bodies, hot subdwarfs [O-B], white dwarfs, quasi-stellar objects, subdwarfs [F-G] and horizontal-branch stars.

Hill and Hill (1966), Lindsay (1966), Grewing (1967), Sandage and Luyten (1967), Sargent (1967), and Sargent and Searle (1968).

The U - B, B - V relation for a black body is nearly a straight line. The main-sequence deviates from the black-body line because of the Balmer jump for high temperatures and because of metallic line depression for low temperatures (Becker, 1963). Hot subdwarfs (O - B), white dwarfs, quasi-stellar objects (QSO), subdwarfs (F - G) and blue horizontal-branch stars occupy areas as shown in Figure 3.1.

3.1.1 Hot subdwarfs

Hot subdwarfs (O - B) fall in the area of very low (U - B) and (B - V) near the main-sequence as shown in Figure 3.1. Below the main-sequence only this type of stars is seen in Figure 3.1. It therefore seems that stars in this area are likely to be hot subdwarfs (O - B). Those hot subdwarfs (O - B) that lie above the main-sequence are, however, easily confused with the bluest white dwarfs.

3.1.2 White dwarfs

White dwarfs fall (as shown in Figure 3.1) above the main-sequence. Most of them gather near the black-body line and about 10% is above the black-body line. The same behaviour is found for early type supergiants, while later ones appear under the black-body line (Becker, 1963). The bluest white dwarfs (DO, DB and hot DAwk) occupy the same region as the hot subdwarfs (O - B) and the hottest main-sequence stars, which was also pointed out by Eggen and Greenstein (1965). Several white dwarfs fall in the area occupied by subdwarfs of spectral types F and G. The areas of white dwarfs and quasi-stellar objects are also over-lapping in the diagram of Figure 3.1.

3.1.3 Quasi-stellar objects

Quasi-stellar objects (QSO) are composed of quasi-stellar sources (QSS) and quasi-stellar galaxies (QSG). QSG are extra-galactic objects which resemble QSS optically but have no strong radio-radiation. From Figure 3.1 we find that most QSO are inside the region:

$(B - V)$: between $- 0\overset{m}{.}2$ and $+ 0\overset{m}{.}6$;

$(U - B)$: between $- 1\overset{m}{.}0$ and $- 0\overset{m}{.}4$.

However, two of them fall in the area occupied by subdwarfs (F - G). The distinguishing ultra-violet excess of QSO relative to main-sequence stars is evident. On the other hand, about 40% falls in the region around and below the black-body line, known to be occupied by white dwarfs. This agrees with previous results by Johnson and Morgan (1953) and by Eggen and Greenstein (1965). The remaining quasi-stellar objects fall above the black-body line in the region also occupied by old novae, SS Cyg, U Gem, and Z And-type variables (Walker, 1957).

3.1.4 Subdwarfs

All except one of the plotted subdwarfs (F - G) form a group in the region shown in Figure 3.1. These subdwarfs (F - G) having $(U - B) > - 0\overset{m}{.}3$ should not enter among the violet stars studied in this investigation. Eggen and Sandage (1965), indicated that the intermediate subdwarfs have a colour excess $\delta(U - B) < 0\overset{m}{.}15$, with $(B - V) > + 0\overset{m}{.}25$, and the extreme subdwarfs have $\delta(U - B) > 0^m.15$, with $(B - V) > + 0^m.35$. Also, subdwarfs with $(B - V)$ between $+ 0^m.4$ and $+ 0^m.9$ can not be distinguished decisively from white dwarfs only on the basis of colour (Eggen and Greenstein, 1965). This agrees with the fact that several white dwarfs fall inside the region of subdwarfs (F - G).

3.1.5 Blue horizontal-branch stars

The HB stars fall along the main-sequence line between $- 0^m.2$ and $+ 0^m.3$ in $(B - V)$. With the criterion used for selecting violet stars, HB stars should be very infrequent among the violet stars found. In the range of $0^m.0$ and $+ 0^m.3$ in $(B - V)$, HB stars fall below the main-sequence curve, as was pointed out by Eggen (1968).

3.2 Classification of Violet Stars according to B - V

Objects for which $(U - B) < - 0^m.6$ are called violet. The violet objects have been divided into four groups according to their value of $(B - V)$.

1. For $(B - V) \leqslant -0^{m}.4$ hot subdwarfs (O - B) should dominate.
2. Main-sequence (O - B) stars, hot subdwarfs (O - B), white dwarfs and quasi-stellar objects occupy the area, $-0^{m}.4 < (B - V) < 0^{m}.0$, and there is no possibility to separate these objects on the basis of UBV photometry alone.
3. Only white dwarfs and quasi-stellar objects are present in the interval $0^{m}.0 < (B - V) < +0^{m}.4$. Of these, the white dwarfs concentrate in the interval of $-0^{m}.9 < (U - B) < -0^{m}.6$. Therefore, nearly all objects occupy the remaining area ($(U - B) < -0^{m}.9$) should be quasi-stellar objects. We note that the interstellar absorption in the high galactic latitudes discussed in this investigation is not sufficient to shift (O - B) stars into this region.
4. For $(B - V) \geqslant +0^{m}.4$ quasi-stellar objects are expected to dominate.

It is noted that a two-colour (U - B, B - V) diagram may be used as a first criterion to separate some quasi-stellar objects from other violet objects. However this criterion alone does not suffice to determine the type of a particular star.

3.3 Two-Colour Diagrams of the Photoelectrically Measured Stars

A two-colour diagram in U - B, B - V of the 43 photoelectrically observed stars is shown in Figure 3.2. Most of these stars fall in the areas occupied by hot subdwarfs and white dwarfs. However, 3 stars (Nos. 48, 162 and 288) fall far above the black-body line in the area occupied by quasi-stellar objects.

A two colour diagram also using the red colour index, V - R', should help to separate quasi-stellar objects from white dwarfs (Braccesi, Lynds and Sandage, 1968). In figures 3.3 and 3.4 are displayed the two-colour diagrams in U - B, V - R' and B - V, V - R' for 25 stars which were observed in all four colours (U, B, V and R'). Two stars (Nos. 48 and 288) show very strong colour in red as well as ultra-violet and these two stars may be quasi-stellar galaxies.

From the photoelectric photometry it appears that Nos. 43, 150, 225 and 278 should not have been accepted as violet, since for them $(U - B) > -0\overset{m}{.}6$. No. 150 is in fact classed as G0 in the HD catalogue (HD 225050). Nos. 225 and 278, however, show a comparatively strong violet image on the U, B plates.

The photoelectric photometry shows that about 50% of the sampled stars have very large ultra-violet excesses compared to main-sequence stars.

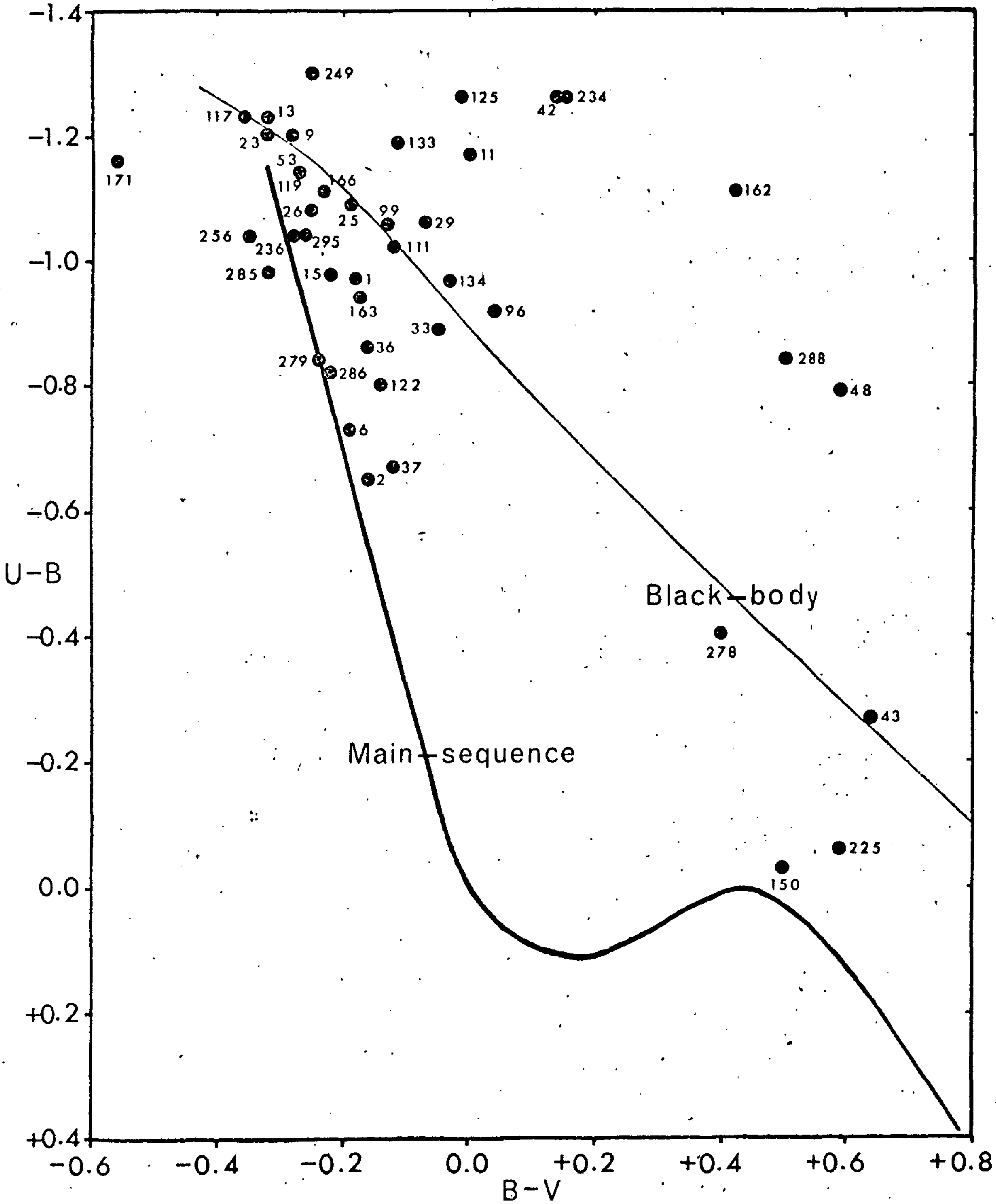


Figure 3.2 A two-colour diagram in U−B, B−V of 43 violet stars.

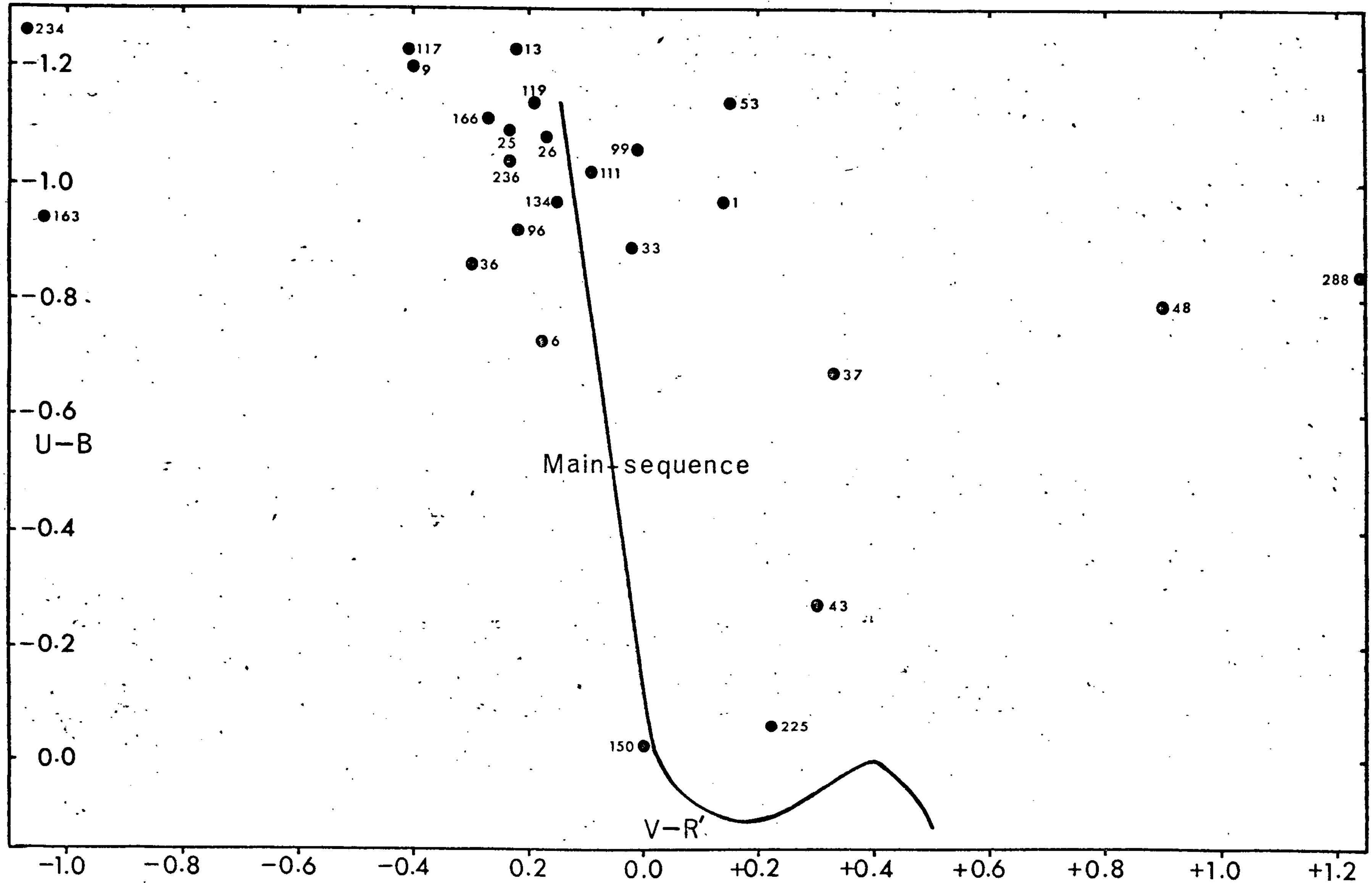


Figure 3.3 A two-colour diagram in U−B, V−R′ of 25 violet stars.

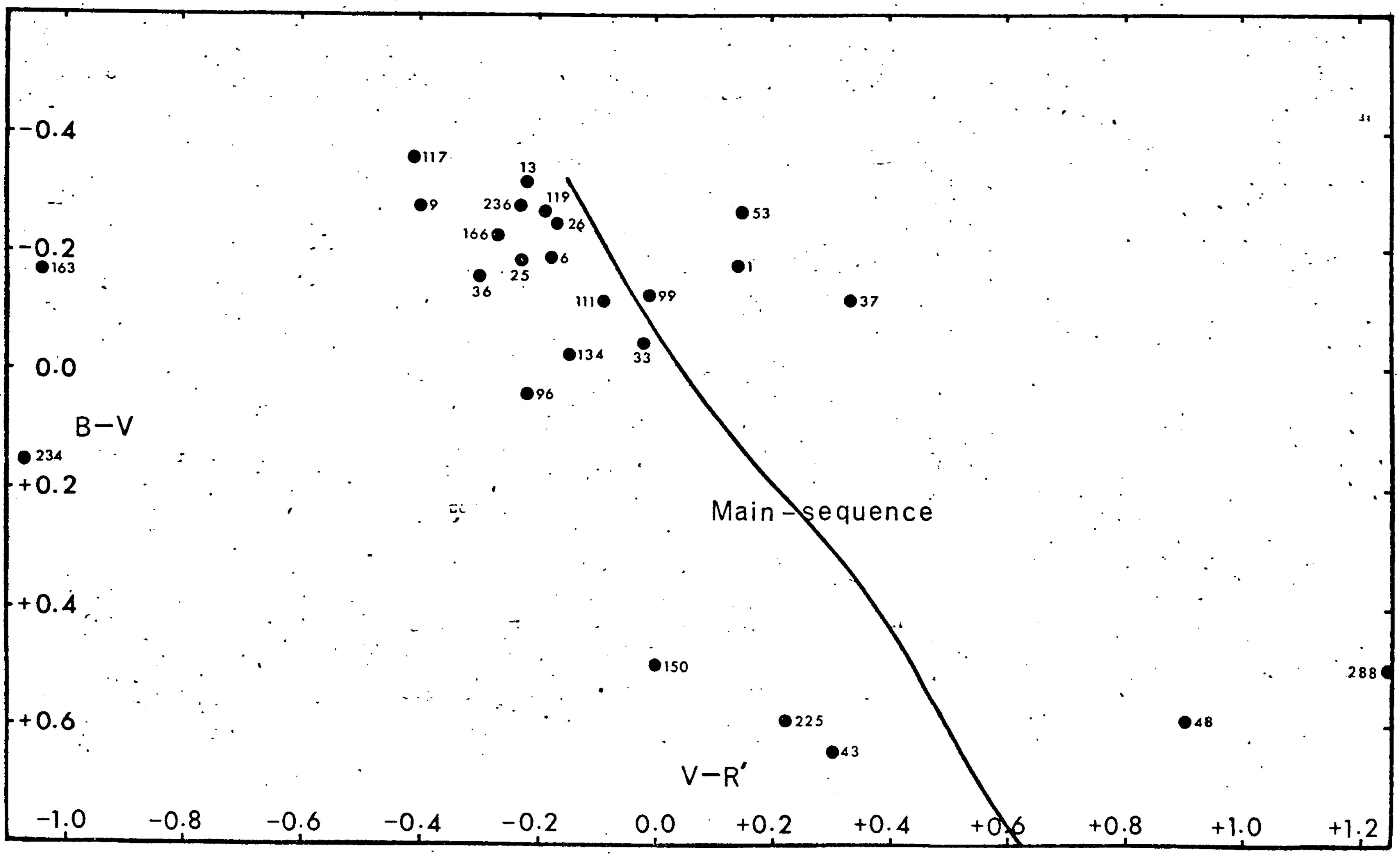


Figure 3.4 A two-colour diagram in B−V, V−R′ of the 25 violet stars.

CHAPTER IV

SPACE DISTRIBUTION

4.1 Introduction

To estimate the expected numbers of white dwarfs, Halo O - B stars and quasi-stellar objects among the violet objects, calculations for various types of stars were made with several assumptions. The intention was to study the differences in population between the brightness groups as denoted by Br (bright), I (intermediate) and F (faint) according to the estimated brightness (see section 2.2.5). The calculations were made for the areas of intermediate and high galactic latitudes separately. The centre of the intermediate latitude area was $b^{II} = -34^{\circ}.7$,

$l^{II} = 314\overset{\circ}{.}13$ and that of the high latitude area $b^{II} = -65\overset{\circ}{.}26$, $l^{II} = 292\overset{\circ}{.}4$. The minimum distance of objects in the intermediate latitude area (I.L.A.) to the galactic centre equals 8.2 kiloparsecs assuming the sun's galactic radius to be 10 kiloparsecs. For the high latitude area (H.L.A.) the corresponding value is 9.9 kiloparsecs. The surface densities of objects (with the exception of quasi-stellar objects) given below were calculated in the range of $m \pm 0.5$ magnitudes within a limiting volume of dv $(dv = V_2 - V_1) = \frac{4}{3}\pi(r_2^3 - r_1^3))$ where r_2, r_1 are distances from the sun corresponding to magnitudes $m + 0.5$ and $m - 0.5$ respectively.

4.2 Expected Numbers

4.2.1 White dwarfs

The calculations of expected surface density of white dwarfs were based on data for B type white dwarfs according to Allen (1963). Thus we assume the space density $\rho = 1.259 \times 10^{-3}$ stars per cubic parsec and an absolute magnitude $M_V = +10\overset{m}{.}4$. The visual absorption is assumed to be 0.8 magnitude per kiloparsec in any direction from the sun (Allen, 1963). Results are shown in Table 4.1 and since they are equally valid in all directions, we may use them for both search areas.

Table 4.1

m	r (pc.)	n
14	52.48	0.02
15	83.18	0.10
16	131.8	0.39
17	208.9	1.34
18	331.1	4.80

r is a distance from the sun in parsecs, and n is the number of white dwarfs per square degree.

4.2.2 Quasi-stellar objects

To calculate the space density of QSG in the two search areas the formula $\log N(B) = 0.75B - 14.0$ (where N(B) is the number of radio-quiet quasars brighter than magnitude B per square degree) given by Sandage and Luyten (1968) was used. For QSS we used the value of 0.0045 per square degree brighter than $B = 18^m$ which was given by Sandage and Luyten (1967). It was assumed that the number of QSS increases by a factor of 5.623 per each increasing magnitude corresponding to the coefficient 0.75 in the above formula given by Sandage and Luyten (1968). In both cases a correction was made for galactic absorption $(A_v) = 0.19$ cosec b^{II}. The results are shown in Table 4.2, from which we see that the surface density of QSG is roughly 75 times that of QSS.

Table 4.2

m	10^3N(QSG) per deg.^{2}		10^3N(QSS) per deg.^{2}	
	I.L.A.	H.L.A.	I.L.A.	H.L.A.
14	0.3	0.5	0.004	0.005
15	1.4	1.8	0.023	0.03
16	10	12	0.13	0.17
17	52	63	0.73	0.96
18	297	360	4.1	5.37

4.2.3 Halo O - B stars

As no estimate of the space density of halo O - B stars is available, we have chosen to study the distribution of RR Lyrae stars, which, if considered representative for the halo, should give some idea of the relative numbers of halo stars in the two areas studied. In these calculations we have again assumed $A_V = 0.19$ cosec b^{II} outside the absorption layer of the Galaxy and the absolute magnitude for RR Lyrae stars has been taken as $M_V = + 0^m.5$.

For RR Lyrae stars brighter than 16^m in the intermediate latitude area and brighter than 15^m in the high latitude area, the calculations were based on data given by Perek (1951) and by Plaut and Soudan (1963). They gave an expression for the logarithm of the number of RR Lyrae stars per cubic kiloparsec for different values of R_o, the distance to the axis of galactic rotation, and Z, the height above the galactic plane. Re-calculated in terms of R, the distance to the galactic centre, and Z, the relation is shown in Figure 4.1.

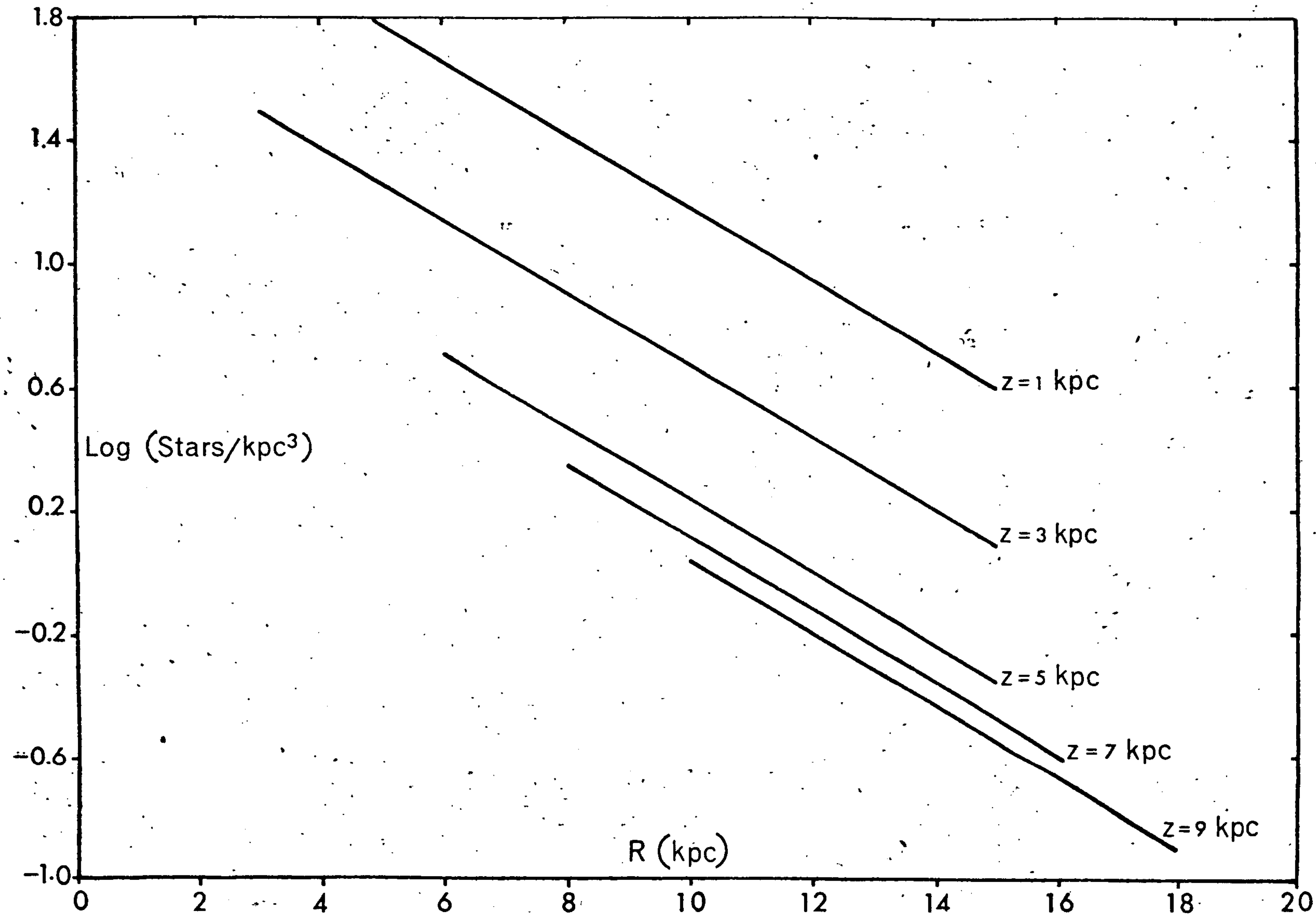


Figure 4.1 Space density of RR Lyrae stars as a function of distances from the galactic centre, R, at different heights, Z.

For RR Lyrae stars fainter than 16^m in the intermediate latitude area and fainter than 15^m in the high latitude area, the calculations were made using the data by Kinman and Wirtanen (1963) who gave the values of the logarithm of RR Lyrae stars ($\log N_m$) at different heights (Z) towards the galactic pole. The following relation was obtained:

$$\log \rho(R) = 155.8R^{-1.902} - 1.1732$$

where $\rho(R)$ = space density of the RR Lyrae stars

and R = distance from the galactic centre.

Table 4.3 contains the results of the expected surface density of the RR Lyrae stars in the two fields.

Table 4.3

m	r (kpc)	R(kpc)		Stars per deg.^{2}	
		I.L.A.	H.L.A.	I.L.A.	H.L.A.
14	5.012	8.230	10.42	0.135	0.035
15	7.943	8.498	11.71	0.215	0.055
16	12.59	10.69	14.74	0.305	0.125
17	19.95	16.43	20.81	0.420	0.240
18	31.62	27.16	31.56	0.570	0.450

r is the distance from the sun and R from the galactic centre.

I.L.A. is the intermediate latitude area and H.L.A. the high latitude area.

4.3 Fenkart's Results on White Stars

To estimate the completeness of the search for violet stars, the surface density of white stars in SA 57 and 54 given by Fenkart (1967, 1968) was studied. For this comparison only stars with $(U - B) < - 0\overset{m}{.}60$ (with the exception of the star No. 807 in SA 54 which has $(U - B) = - 0\overset{m}{.}59$) given by Fenkart were considered as violet. The visual absorption was assumed to be 0.19 cosec b^{II} in both areas and it was assumed that the number of stars increases by the factor 3.981 per magnitude.

Table 4.4 shows the position and the size of the areas studied in SA 54 and 57.

Table 4.4

Field	l^{II}	b^{II}	Area (deg.^{2})
SA 54	199°	+ 59°	2.56
SA 57	67°	+ 89°	2.61

To transform colour of the white stars from the UGR (here called U'GR) system to the UBV system, the equations given by Becker (1965) were used in the following form:

$$(U - B) = 0.92(U' - G) - 0.06(G - R) - 1.13$$

$$(B - V) = 0.03(U' - G) + 0.87(G - R) - 0.32$$

$$V = G + 0.08(U - B) - 0.93(B - V).$$

The surface density of violet stars (based on the data by Fenkart) brighter than a limiting magnitude (m) is shown in Table 4.5.

Table 4.5

m	Stars per deg.^{2}	
	SA 54	SA 57
14	0.008	0.002
15	0.034	0.009
16	0.135	0.036

4.4 Expected Numbers of Different Types of Stars in Both Areas

Using the above calculations we can estimate the numbers of stars of different types which are expected among the catalogued stars.

In the intermediate area the author found 158 violet stars comprising 58 stars classed Br and I and 100 stars classed F (where Br = bright, I = intermediate and F = faint, see sections 2.2.5 and 2.2.6). In the high latitude area 53 Br and I stars and 85 stars of brightness class F were found.

To estimate the numbers of white dwarfs (WD), Halo O - B stars (H), quasi-stellar galaxies (QSG) and quasi-stellar sources (QSS) in both areas, it was assumed that Halo O - B stars have

(a) the same space density as RR Lyrae stars (Table 4.6) or

(b) $\frac{1}{10}$ of the space density of RR Lyrae stars (Table 4.7).

It must be emphasized that the basis for these assumptions is weak, particularly considering inhomogeneities of the halo as pointed out by Fenkart (1968). However, no other possibility seems open, and it would seem that at least an upper limit to the number of expected O - B stars is obtained.

Table 4.6

Brightness classes	Expected numbers of objects in I.L.A.				Expected numbers of objects in H.L.A.			
	WD	H	QSG	QSS	WD	H	QSG	QSS
Br + I	25	32	1	-	37	15	1	-
F	82	13	5	-	72	8	5	-

Table 4.7

Brightness classes	Expected numbers of objects in I.L.A.				Expected numbers of objects in H.L.A.			
	WD	H	QSG	QSS	WD	H	QSG	QSS
Br + I	50	7	1	-	50	2	1	-
F	93	2	5	-	79	1	5	-

4.5 Actual and Binomial Distribution of the Violet Stars

Statistical tests were made on possible clustering effects of the positions of the violet stars. Coordinates of the stars in α and δ were converted into rectangular coordinates in x and y. The stars with coordinates (x_i, y_i) were plotted, and tests were made of the distribution of stars in the various brightness and colour classes. Forty stars in the outskirts of the studied areas were excluded for practical reasons. It was found that the actual distribution of the stars agrees closely with the binomial distribution expected for random distribution of the stars. This shows that:-

1. There is no clustering of the violet stars studied,
2. no particular area shows large scale absorption patterns, and
3. the difference between the stellar distribution in the two areas is negligible.

4.6 Discussion

The following points can be made on the basis of Tables 4.5, 4.6 and 4.7:

1. White dwarfs are dominant in both areas particularly for faint stars.

   If the absolute magnitude assumed for the white dwarfs is too low, which may be the case as some of the stars included are of later spectral types than B, the dominance of white dwarfs is even larger than indicated in the tables.
2. A change in the assumed space density of Halo O - B stars by a factor of 10, does

not severely effect the expected number of QSG. Particularly, we find that the number of halo stars decreases with increasing magnitude while the numbers of white dwarfs and quasi-stellar objects increase.

3. The expected number of QSS is about 75 times less than that of QSG so that we would not expect to find any QSS among the catalogued stars. The positions of the catalogued stars were compared by Dr. J. Shimmins of CSIRO, Sydney with radio source positions obtained at Parkes. No clincidence was found.

4. In the area of intermediate latitude we find 0.22 stars of brightness classes Br and I per square degree and 0.39 faint (F) stars per square degree. The corresponding values for the high latitude area are 0.19 and 0.31, i.e. the difference between these areas is insignificant in this respect, which was also found in section 4.5.

5. According to Fenkart's results regarding the surface density of violet stars (section 4.3) our search should be complete to $B = 17^m$ which well agrees with an estimate based on the observed plate limit. With the expected number of QSO in the search areas a surface density of 0.022 QSO per square degree brighter than $B = 17^m$ is expected. According to Sandage and Luyten (1968) one should find 0.056 QSO per square degree for the same magnitude limit, indicating that our expected number of QSO is less than that given by Sandage and Luyten by a factor of 2.5. This is partly due to the restriction to objects with $U - B < - 0\overset{m}{.}6$ in the present work.

CONCLUSIONS AND COMMENTS

As a result of this work, it is concluded that -

1. The search for faint blue stars in the northern hemisphere is more complete than in the south. Observations for violet stars with $B > 17^m$ are needed in the southern hemisphere particularly around the south polar cap.
2. The violet stars presented in the text are generally more violet than the average LB stars. It is therefore

believed that among them should be a relatively high proportion of quasi-stellar galaxies.

3. There are two possible quasi-stellar galaxies among the 43 sampled objects that were measured photoelectrically. If this is any indication of the number of quasi-stellar galaxies among the violet objects then we might expect a dozen or more quasi-stellar galaxies among the 296 violet objects found. This agrees with the estimated frequency of quasi-stellar galaxies as found in chapter IV.

4. Based on photoelectric results only, it is difficult to judge whether the violet stars are extra-galactic objects. Spectroscopic observations are needed for this work.

REFERENCES

Allen C.W. 1963, Astrophys. Quantities, (London: Athlone Press), pp. 199, 237 and 251.

Becker, W. 1963, Stars and Stellar Systems, ed. K. Aa. Strand (Chicago: The University of Chicago Press), 3, 253.

Becker, W. 1965, Z. Astrophys., 62, 54.

Blanco, V.M. 1956, Astrophys. J., 123, 64.

Braccesi, A. 1967, Observations of the Owens Valley Radio Obs., No. 2.

Braccesi, A., Lynds, R., and Sandage, A. 1968, *Astrophys. J.* (Letters), 152, L 105.

Brooke, A.L. 1968, (Private communication).

Chavira, E. 1958, *Bol. Obs. Ton.*, 2, No. 17, p. 31.

Chavira, E. 1959, *ibid.*, 2, No. 18, p. 30.

Cowley, C.R. 1958, *Astron. J.*, 63, 484.

Eggen, O.J. 1968, (Private communication).

Eggen, O.J., and Greenstein, J.L. 1965, *Astrophys. J.*, 141, 83.

Eggen, O.J., and Sandage, A. 1965, *Astrophys. J.*, 141, 821.

Elvius, T., and Lyngå, G. 1965, *Uppsala Astr. Obs. Medd.*, No. 149.

Feige, J. 1958, *Astrophys. J.*, 128, 267.

Fenkart, R.P. 1967, *Z. Astrophys.*, 66, 390.

Fenkart, R.P. 1968, *ibid.*, 68, 87.

Greenstein, J.L. 1960, *Stars and Stellar Systems*, ed. J.L. Greenstein (Chicago: The University of Chicago: Press), 6, 676.

Greenstein, J.L. 1966, *Astrophys. J.*, 144, 496.

Grewing, M. 1967, *Astrophys. J.*, 148, 705.

Haro, G., and Luyten, W.J. 1962, *Bol. Obs. Ton.*, 3, 22.

Hill, P.W., and Hill, S.R. 1966, *Monthly Notices Roy. Astron. Soc.*, 133, 205.

Hiltner, W.A., and Johnson, H.L. 1956, _Astrophys. J._, _124_, 367.

Humason, M.L., and Zwicky, F. 1947, _Astrophys. J._, _105_, 85.

Iriarte, B., and Chavira, E. 1957, _Bol. Obs. Ton._, _2_, No. 16, p. 36.

Johnson, H.L. 1962, _Stars and Stellar Systems_, ed. W.A. Hiltner (Chicago: The University of Chicago Press), _2_, 157.

Johnson, H.L. 1966, _Ann. Rev. Astron. Astrophys._, _4_, 193.

Johnson, H.L., and Morgan, W.W. 1953, _Astrophys. J._, _117_, 313.

Kinman, T.D., and Wirtanen, C.A. 1963, _Astrophys. J._, _137_, 698.

Lindsay, E.M. 1966, _Irish Astron. J._, _7_, 257.

Luyten, W.J. 1952, _A Search for Faint Blue Stars_, (The Observatory: University of Minnesota), No. I.

Luyten, W.J. 1954, _ibid._, No. II.

Luyten, W.J. 1956, _ibid._, No. IV.

Luyten, W.J. 1957, _ibid._, No. X.

Luyten, W.J. 1961, _ibid._, No. XXVI.

Luyten, W.J. 1966a, _ibid._, No. XXXVIII.

Luyten, W.J. 1966b, _ibid._, No. XXXIX.

Luyten, W.J., and Anderson, J.H. 1958, *A Search for Faint Blue Stars*, (The Observatory: University of Minnesota), No. XII.

Luyten, W.J., and Anderson, J.H. 1959, *ibid*., No. XVIII.

Luyten, W.J., and Anderson, J.H. 1967, *ibid*., No. XILIV.

Luyten, W.J., and Smith, J.A. 1958, *Magnitudes and Colours for Southern White Dwarfs*, (The Observatory : University of Minnesota).

Malmquist, K.G. 1927, *Lund Medd. Ser. II*, No. 37.

Malmquist, K.G. 1936, *Stockholm Obs. Ann.*, *12*, No. 7

Matthews, T.A., and Sandage, A.R. 1963, *Astrophys. J.*, *138*, 30.

Sandage, A. 1964, *Astrophys. J.*, *139*, 442.

Sandage, A. 1965, *ibid.*, *141*, 1560.

Sandage, A.R., and Luyten, W.J. 1967, *Astrophys. J.*, *148*, 767.

Sandage, A.R., and Luyten, W.J. 1968, (Private communication).

Sandage, A., and Walker, M.F. 1964, *Astrophys. J.*, *143*, 313.

Sargent, W.L.W. 1967, *Astrophys. J.*, *148*, 147.

Sargent, W.L.W., and Searle, L. 1968, (Private communication).

Shimmins, A.J., Clarke, M.E., and Ekers, R.D.	1966,	Aust. J. Phys., 19, 649.
Slettebak, A., Bahner, K., and Stock, J.	1961,	Astrophys. J., 134, 195.
Perek, L.	1951,	Brno. Contr., 1, No. 8.
Plaut, L., and Soudan, A.	1963,	Bull. Astron. Inst. Neth., 17, 70.
Walker, M.F.	1957,	Intern. Astron. Union Symp. No. 3, ed. G.H. Herbig (Cambridge: The University Press), p. 46.